Vol. 15, No. 7 July, 1959

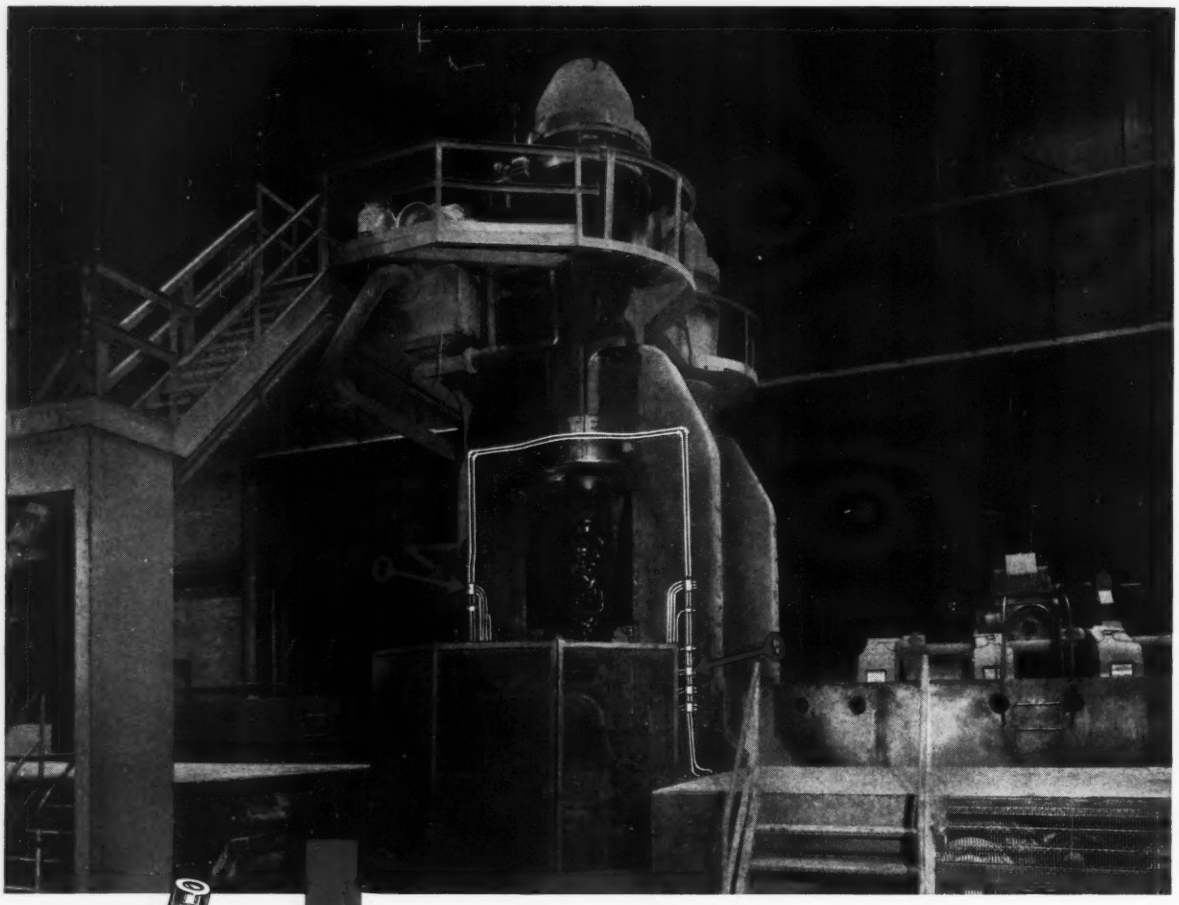
LUBRICATION ENGINEERING

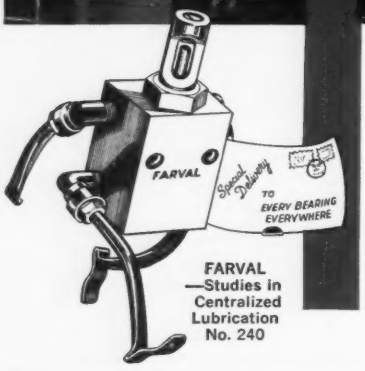
DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

in this issue:

Jet Engine Lubrication

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS





FARVAL
—Studies in Centralized Lubrication
No. 240

Farval automatic systems lubricate Geneva Works 45-inch slabbing mill

The fast and synchronized action of this 45-inch slabbing mill at the Geneva Works of Columbia-Geneva Steel Division, U. S. Steel Corporation depends to a large extent on properly lubricated bearings. Sixteen Farval systems automatically lubricate more than 1,000 bearings throughout the slabbing mill. Other Farval systems serve more than 6,000 bearings at the Geneva Works. Lubricant in the correct amount is delivered at regular intervals under the most rugged conditions and combinations of heat, shock and vibration.

Case histories prove Farval lubricating systems more than pay for themselves in savings of bearing loss, excessive lubricant and improved housekeeping practices.

Now is the time to find what Farval can do for you —

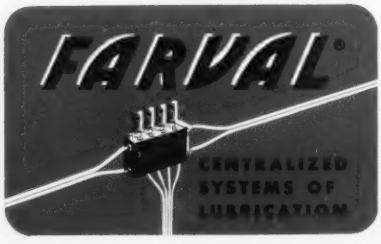
There is a Farval System to meet almost *every* lubrication requirement. Write for Bulletin 26-S.

The Farval Corporation, 3267 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company
(Subsidiary of Eaton Manufacturing Company)

KEYS TO ADEQUATE LUBRICATION

Wherever you see the sign of Farval—familiar valve manifolds, dual lubricant lines and pump stations —you know steel mill equipment is being properly lubricated.



Volume 15, No. 7
July, 1959

Lubrication Engineering

DESIGN RESEARCH APPLICATION EDUCATION MAINTENANCE

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Cover photo courtesy United Air Lines

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LUBRICATION IN THE NEWS

Soviets Believed "Not Ahead" of U. S. in Lubricants to 1958

Soviet literature indicates that Russia and her satellites were not ahead of the United States in the field of lubricants and lubrication at the beginning of 1958, but were trying to gain headway by studying the work of others.

According to a survey of published Russian literature by a U. S. Government agency, "It appears that Soviet scientists are not ahead of any process, products, or applications." The study included material on lubrication, lubricants and additives, and formulation of lubricating compositions.

The survey involved review of abstracts of some of the Russian technical reports appearing from 1950 to the end of 1957. It has just been released to the public as a report through the Office of Technical Services, U. S. Department of Commerce.

Red-nation researchers were apparently concentrating on areas fairly well known and defined by U. S. scientists.

This may mean, the survey concludes, that the Soviets realized the potential importance of the field; that they were not especially proficient in it; and that the way to get established was to familiarize themselves with lubrication science and technology by checking the work of others.

Specifically, no clear-cut references were found to work being conducted on, or use of, synthetic esters as base stocks. Where lubricants were cited, it appeared that conventional petroleum products from Soviet refineries and crude sources were used. Also, no new or novel methods were being used to provide lubrication at extremes of temperature or extremes of equipment usage.

The greatest number of references related to phosphorus chemistry, but there was no certain evidence that organophosphorus compounds were to be used as lubricant additives.

A large amount of research was being expended on hydrocarbon chemistry, an effort which could, the report observes, lead to new petroleum processes and products.

The volume is 59-11902 Soviet Research in Lubricants and Lubrication, Dec. 1958, distributed by OTS, U. S. Department of Commerce, Washington 25, D. C. It contains 27 pages, price 75 cents.

Patent Granted for New Grease

Witco Chemical Company, Inc., has been granted U. S. Patent 2,859,179 covering a grease composed of lubricating oil and, as thickening agent, a metallic soap (preferably aluminum) of which the fatty acid portion is a mixture of monocarboxylic and sebacic acids.

In testing-machine performance, grease produced according to this patent is reported to show no substantial breakdown below 100,000 strokes.

The soap specified in the patent is covered by Witco Patent 2,699,428, and licenses to produce it are available upon request.

Witco Chemical Company will also license any manufacturer to use the procedures outlined in Patent 2,859,179

Manufacturers that purchase soap made according to Patent 2,699,428 from Witco or its licensees may market the grease produced therefrom without the payment of royalties.

Hydraulic Fluid Leakage Cut

Philadelphia, May 18.—A recently completed field test installation reportedly indicates that antileak oils can reduce hydraulic fluid losses by as much as 35 per cent.

The test, conducted jointly by a leading aircraft research center and Sun Oil Company, involved a centralized lubrication and hydraulic system for the compressor and air exhaust equipment, servicing various high speed tunnels and test stands. The blower equipment consists of ten centrifugal compressors, all driven by electric motors of 10,000 to 18,000 hp each. Total horsepower required is 162,000.

Prior to the test study, the oil used was Government Spec. 3042 (125 SUS at 100 F). It lubricated motor and blower babbitted bearings turning at 3,600 rpm. The oil also served as the hydraulic medium for hydrometer-driven controls, such as air valves in high-velocity ducts 5 ft. and more in diameter. Hydraulic pressures are about 150 psi and 300 psi, and operating temperature of the lubricant was about 120 F. There is a 10,000 gallon reservoir which holds the oil for the combined system.

Oil had been leaking through the bearing seals and packing glands. In addition, high-frequency vibration was believed to be loosening the threads of the hydraulic lines, "not enough to allow an extra turn of a joint, but enough to cause bad leaks." Make-up of 10 per cent per month, or about 5 drums per week was required to keep the system full during maximum operation. In addition, many man-hours per month were required to clean up oil dripping from hydraulic air-control valve mechanisms and from unidentifiable sources up among the ducts in the basement of the building. Concrete foundations under the equipment were black with oil, although the installation was only four years old. The basement was being steam-cleaned once each month and plant-fabricated drip pans, suspended below as many of the known drip spots as possible, were being used to divert oil into plastic tubes leading to salvage drums placed around the basement floor.

To determine the feasibility of using a leakproof oil, a self-contained circuit within the hydraulic system was isolated. Leakage from individual joints was then measured before and after charging the circuit with the Suntac lubricant. The oil which had previously been used leaked about one pint per day from a typical joint, as compared to about one ounce in 18 days from the same location after changing to Suntac. On an overall basis, leakage was reduced 35 per cent with Suntac, a saving of about 4,000 gallons per year.

INDUSTRY NOTES

Texaco (formerly the Texas Co.) has begun construction of a sulfuric acid type alkylation unit and a butane unit at its Tulsa refinery.

Product Maintenance Inc., Chicago, which specializes in sales and service of paint spraying, lubricating, coolant and parts cleaning equipment, has opened a Wisconsin division in Milwaukee.

ASLE MEMBERSHIP CLASSIFICATIONS

Membership in the American Society of Lubrication Engineers is in several grades as defined below. Assignment to grade is made by the Admissions Committee or Board of Directors on the basis of information submitted by the applicant.

Members: Members shall be persons not less than 24 years of age who: (1) are engaged in research and instruction at technical schools, universities, and various publicly and privately supported institutions in the field of lubrication; or (2) have occupied recognized positions as lubrication engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibility for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge, and accomplishment, and have manifested a particular interest in the purposes and welfare of the Society to the extent that their membership would be a valuable contribution to the successful functioning of its activities. Fee 15.00.

Associate Members: Associate Members shall be persons less than 24 years of age, and those who do not completely fulfill the membership requirements for Members. Fee $7.50.

Sectional Sustaining Members: are such persons or organizations as may be interested in and desire to contribute to the support of the purposes and activities of a local Section of the Society. Fee $25.00.

Industrial Members: Industrial Members are such persons or organizations as may be interested in and desire to contribute to supporting the purposes and activities of the Society. Fee $150.00.

For application blanks or further information, write:

ASLE
5 N. Wabash Ave.
Chicago 2, Ill.

PRODUCT LITERATURE

ADJUSTABLE-SPEED DRIVE

Adjustable-speed and drive control problems are discussed in a new booklet produced by Cleveland Worm Gear's Speed Variator Division. Designated Bulletin No. K-250, the booklet presents eight pages of typical applications along with methods and types of remote and automatic control, plus variable speed bedplate assemblies. Available upon request to The Cleveland Worm & Gear Co., Speed Variator Div., 3300 East 80th St., Cleveland 4, O.

ROLLER BEARINGS DESCRIBED

A catalogue just published by the Rollway Bearing Co., gives information on the features, applications, and availability of the company's nine principal lines of roller bearings. Generously illustrated, the two color catalogue describes the general features of this company's bearings and indicates the range of sizes in which they are offered. Included is a description of the company's manufacturing, research and development, design and testing facilities. Bearing specifications, general features, size availability and application data are included on the following Rollway bearings: Air-Rol, precision radial, Tru-Rol, precision thrust, steel cage, (both inch and metric), Flexi-Flange, cartridge, and traction motor bearings. Another section deals with the bearings that the company designs and manufactures for unusual applications where race configuration, material, or unusual construction is required. Several illustrations and descriptions of bearings are included. The catalogue is designed as a handy, condensed, full line reference for manufacturers, designers and engineers. Copies may be obtained by writing for Rollway Product Line Catalogue, PL-559, to the Rollway Bearing Co., Syracuse 4, N. Y., or to any of their branch offices.

CHART HELPS CHOOSE PROPER LUBRICANT

Bulletin 121, a lubricant selector chart which facilitates the choice of the proper lubricant for practically any extreme pressure lubrication job, has been just published by The Alpha-Molykote Corp. The selector chart evaluates every type in the manufacturer's lubricant line based on temperature, environment, method of application, incorporation into common materials, and recommendations for various parts, operations and conditions. A brief technical description of each type is also included. Copies may be obtained from The Alpha-Molykote Corp., Stamford, Conn.

CATALOG REVIEWS BEARINGS

Condensed catalog 59A covers the complete line of Shafer self-aligning roller bearings, offers assistance in the proper selection of bearing equipment for greater speed, higher load capacities and longer wear life. Catalog 59A contains information on roller bearing design, specifications, lubrication, seals and installation features. Copies may be obtained by contacting a Chain Belt distributor or district office, or by writing direct to Chain Belt Co., Sales Promotion Dept., Milwaukee 1, Wisc.

PERSONALS

John K. McKinley has been appointed assistant to the vice president in charge of Texaco Company's Research and Technical Department.

Edward G. Timmerman of Mt. Clemens, Michigan, recently became associated with the Engineering and Sales Department of the Brooks Oil Company, Cleveland, Ohio.

Robert M. Curts has been assigned manager of glass and ceramic industry sales of American Potash & Chemical Corp. Curts will continue his duties as manager of boron products sales.

J. Fryzel was promoted to vice-president in charge of sales for R.I.T.A. Chemical Corp.

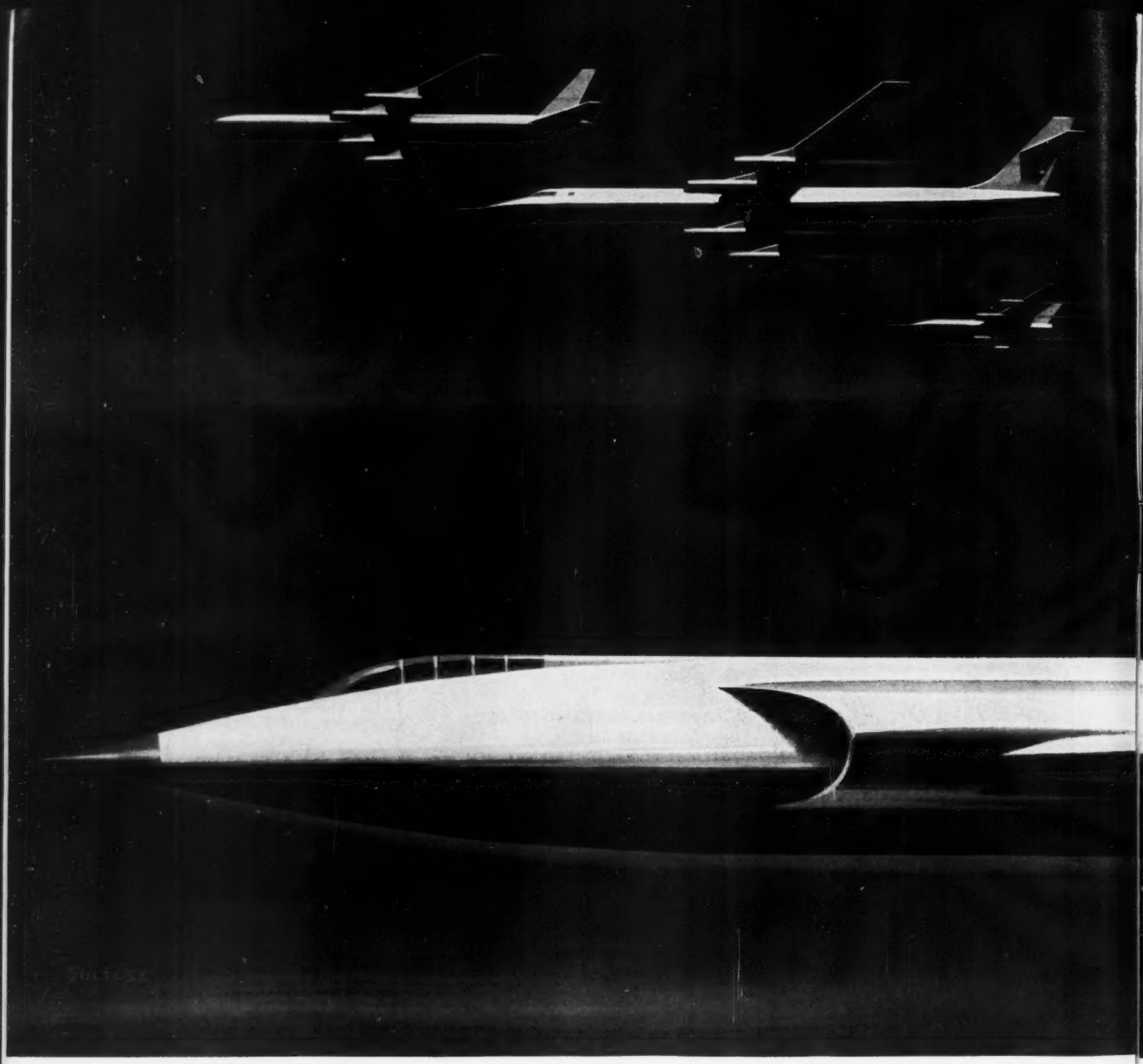
Allen Jaffy was designated as division controller of the Dyestuff & Chemical Division, General Aniline & Film Corp.

Sumner B. Twiss has been named president of Chrysler Corp.'s Cycleweld chemical products division, Trenton, Mich.

Oronite Chemical Company has announced the appointment of W. K. Venatta as manager of the company's Manufacturing Department.

Three new directors of Reynolds Metals Company were elected to succeed retiring members at the annual meeting of the company's stockholders. New board members are William T. Brunot, controller; Allyn Dillard, corporate secretary; and Gustab B. Margraf, general solicitor. They succeed

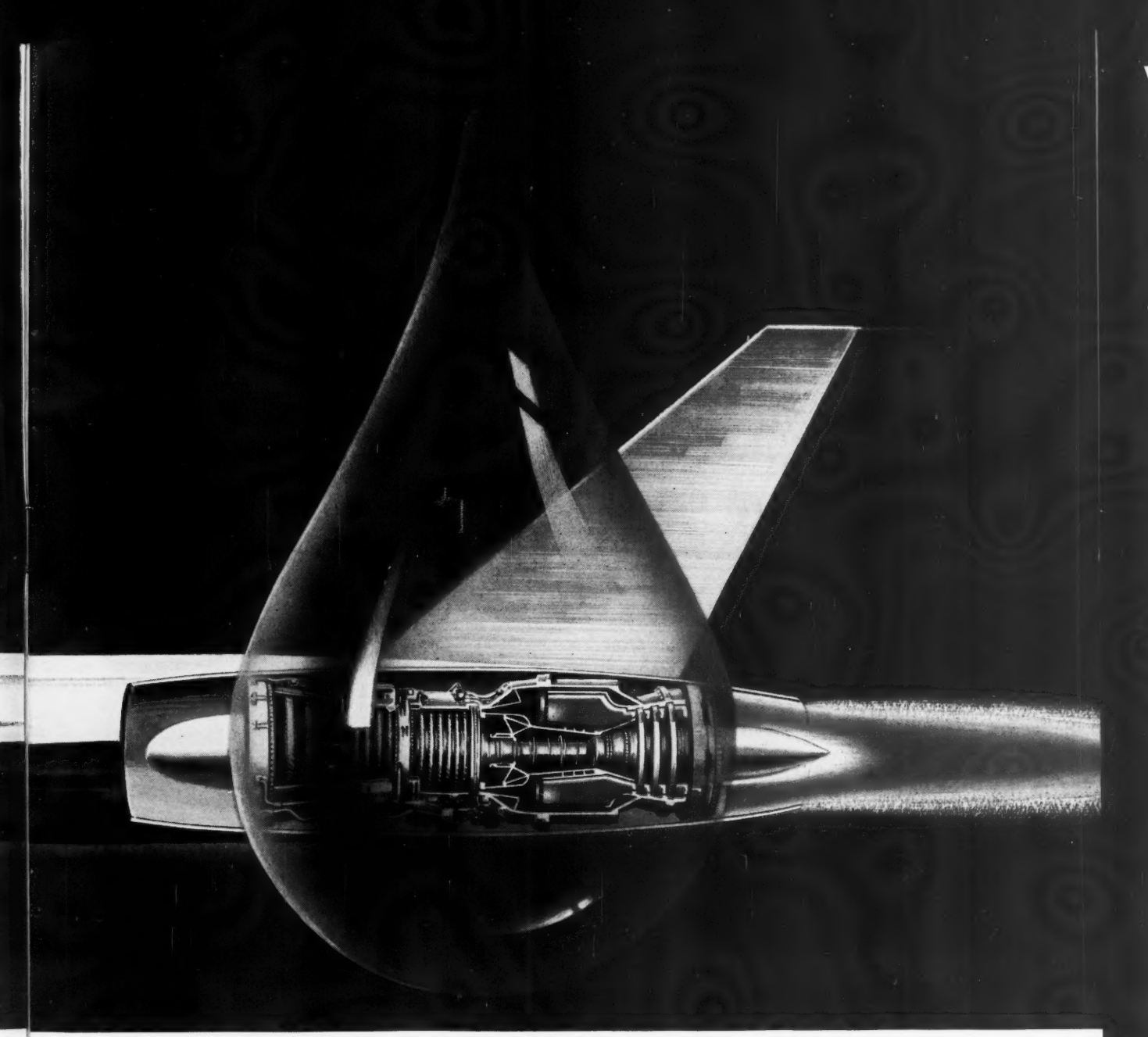
(Cont. on p. 274)



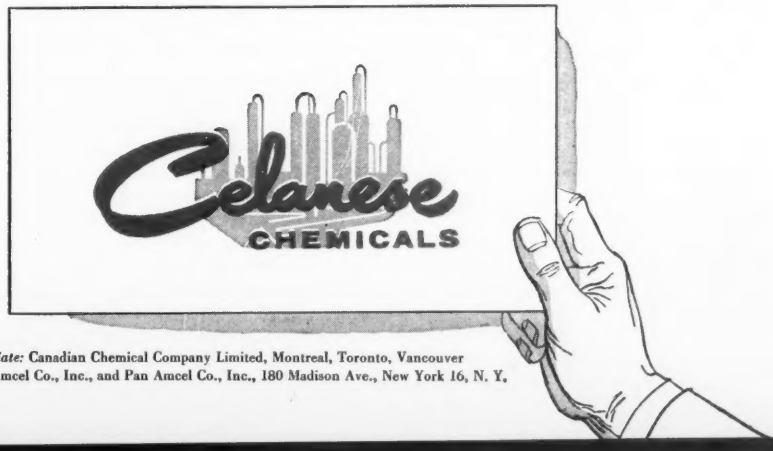
Lube "breakthrough" by Celanese

New Celanese synthetic lubricants have hurdled the heat barrier set up by high bulk oil temperatures in jet engines. These lubricants withstand 425°F . . . more than 100° higher than any previously available. Highly significant, too, is the fact that they efficiently meet viscosity requirements at temperatures down to −65°F. Their potential has barely been tapped. For instance, they may become of utmost importance in such broad fields as heat transfer, automotive, and steel and aluminum forming. Continuing research and progress by Celanese in high-temperature lubricants has broadened and sharpened our national defense capabilities and has enabled great improvement in industrial machinery design. If you have a high-temperature lube problem, why not ask us to help? Simply write to Celanese Corporation of America, Chemical Division, Dept. 579-G, 180 Madison Avenue, New York 16, New York.

Celanese®



opens the way for new superspeed jets

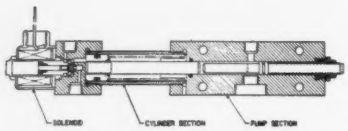


Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Ave., New York 16, N. Y.

NEW PRODUCTS

NEW POSITIVE DISPLACEMENT PUMP

The new Airmatic VC 1000-1 positive displacement pump is reported by the manufacturer to be ideal for slug feeding of precise quantities of greases, slurries, pastes, and other viscous liquids and semiliquids. The unit consists of a solenoid actuated pneumatic cylinder and a pumping head which contains inlet and outlet ports and provision for precise limitation of the length of stroke of the air cylinder piston. The metering pump



provides precision metering of even heavy-bodied liquids since pumping pressure can be as high as 354 psi. Pumping pressure is determined by air pressure (up to 200 psi) and air cylinder bore (1, 1⅛, and 1½ in.). Air ports are ¼ in.; cylinder stroke is 0 to 2 in.; fluid line connections are ¼ in. Pumping capacity range is 0 to 6.44 cc. Solenoids are available for most ac or dc voltages. Materials employed in pumping head and piston can be varied to suit requirements of material being pumped. Additional information available from Airmatic Valve, Inc., 7313 Associate Ave., Cleveland 9, Ohio.

LUBRICANT COMBATS WEATHER CONDITIONS

A new, durable, open gear lubricant called Gredag 98 is available in a caulk type cartridge and provides a user with a superior lubricant to combat adverse weather conditions. It is manufactured from specially selected raw materials that reportedly insure freedom from dripping, thinning and throw-off in service. Easy to apply at low temperatures, the lubricant retains plasticity below freezing. The spouted caulk type cartridge eliminates waste and contamination and can be used in an inexpensive caulking gun available at most hardware or mill supply stores. For further information, write Gredag Dept., Acheson Colloids Co., Port Huron, Mich.

COMPANY ANNOUNCES PUMP AND MOTOR COMBINATION

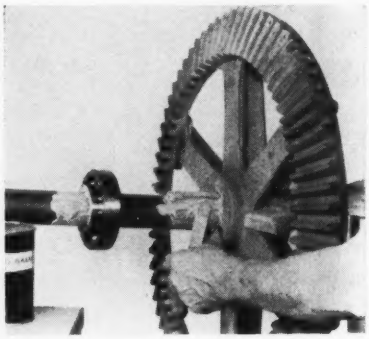
The Tuthill Pump Co., 971 E. 95th St., Chicago, Ill., recently announced the addition of a new Series 42 pump and motor combination to its line. Developed specifically for applications where space and weight are at a premium the new unit measures only 9⅛ in. × 5 in. It incorporates a totally enclosed electric motor rated for 1/12th to ⅙th horsepower, and an internal gear pump with a capacity of from ⅓ to 3 gpm. Twenty-four models are supplied in the series. All of them can be furnished either with or without a built-in relief valve. Tuthill also supplies a complete selection of other close coupled pump and motor combinations with capacities up to 50 gpm, for pressures to 400 psi. All are immediately available from stock. They have been used in a wide variety of hydraulic, oil burning, lubrication, and other services. The complete line includes a broad selection of positive displacement rotary pumps with capacities from ⅓ to 200 gpm; for pressures to 1500 psi speeds to 3600 rpm.

DISPENSER FOR RUST PREVENTIVE

Rust-Lick, Incorporated announces that Rust-Lick 606 moisture absorbing rust preventive is now available in a fog-maker dispenser. Rust-Lick 606 assures positive protection against rust and was developed for applications where spraying methods are most advantageous, and where drying or removal of moisture is not practical or is too costly. The Fog-Maker makes application comparatively simple. The dispenser has a positive trigger-action pump; it operates with one hand; no electricity, air compressor or CO_2 cartridges are required. When sprayed, it produces a thin, oily film after evaporation of the high flash solvent component. The residual film is non-drying; it functions as a lubricant; and is easily removed by wiping, alkaline washing or degreasing. Rust-Lick functions equally well when sprayed on either wet or dry surfaces. It is recommended for protection of dies, tools, machinery, jigs, fixtures, unfinished work or raw stock during indoor storage or shipment. Fog-Maker Bulletin #62 gives details. Write Rust-Lick, Inc., 755 Boylston St., Boston 16, Mass.

LUBRICANT MINIMIZES GALLING

A specialized lubricant that is said to prevent galling and corrosion of tapped threads in construction, mining, quarrying, and oil field drilling equipment and that serves as an effective anti-friction, anti-seize compound for certain metalworking, general industrial and marine applications, has recently been announced by Keystone Lubricating Co.



This product protects drilling equipment—jackbits, drill rods and couplings, oil well casings, and drill pipes—against thread damage due to corrosion, stripping and galling. In general industrial use, this lubricant protects machine slides and lathe dead centers from excessive frictional wear, serves as a superior drawing and forming compound, provides an effective moisture-resistant gasket seal, and virtually eliminates the possibility of seizing and galling in press fitting operations, keyway lubrication and other high pressure applications. In the marine field, this lubricant provides effective lubrication for such equipment as clevises, turn buckles and standing falls. Keystone No-Gall is a zinc-base lubricant made in plastic consistency for brush or paddle application. It reportedly does not dry out or harden. Additional information is available from Keystone Lubricating Co., 3100 N. 21st St., Philadelphia 32, Pa.

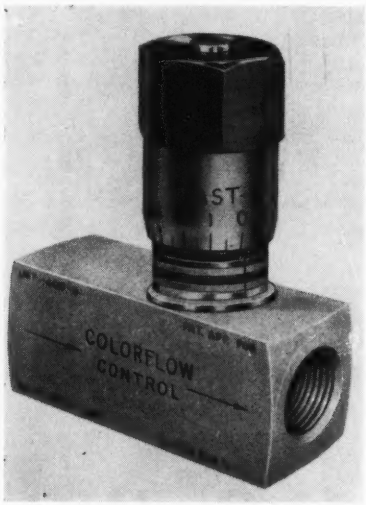
NONIONIC OILS AVAILABLE

A new series of three nonionic coning oils, used primarily for textured yarns and nylon filament yarn for hosiery knitting, are now being introduced. Known as Textilines, they are extremely

light colored oils, stable to oxidation and discoloration with built-in static inhibitor. Textiline 3233 is recommended for application to bulk yarn such as Fluflon, Helenca, Saaba, Taslan, etc. It imparts proper lubricity to permit the formation of soft and even cones of uniform density, and is claimed to assure superior knitting performance. Textiline 3000 is specifically designed for preparing Ban-Lon, a nylon yarn where low yarn-to-metal friction and low tension in coning and knitting are essenital. Textiline 3199 is suggested for sized and unsized nylon yarn for hosiery knitting. It contributes to uniform stitch formation and will not adversely affect the size. Information on Textiline 3233, 3000, 3199, is available from the Dept. of Industrial Research, L. Sonneborn Sons, Inc., 300 Fourth Ave., New York, N. Y.

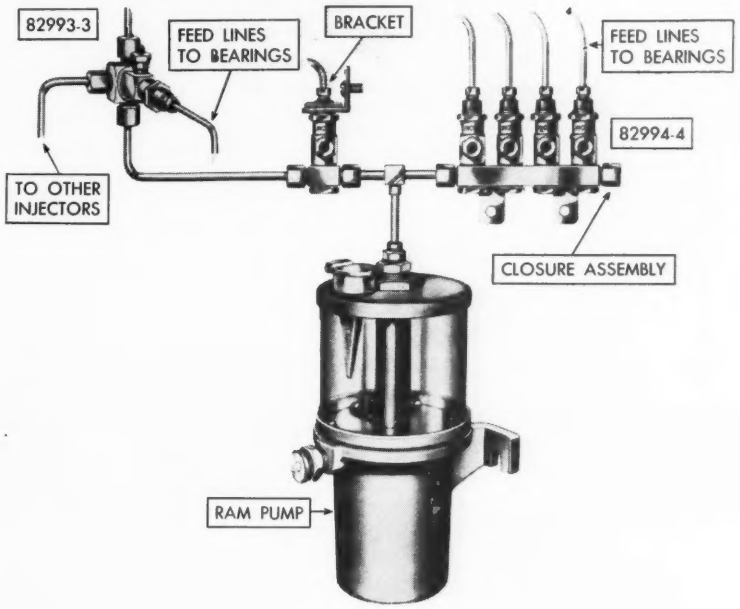
VALVES FEATURE COLOR-CODE

A control valve suitable for use with air, oil, gas, water or other fluids has been developed by The Manatrol Corporation, 2108 Payne Ave., Cleveland, Ohio. The new valve, is unique in that the adjusting scale is composed of permanently easy-to-read color graduations. It is expected to simplify many basic control problems, whether on a single machine or in an entire plant.



The color coding is claimed to enable even untrained personnel to check the valve setting at a glance, make quick adjustments, record the reading, and reset the valve when necessary. It simplifies the problem of presetting the valve to a predetermined value and eliminates the human errors encountered with the hit-or-miss method of counting the number of times the screw must be turned to set or reset a valve. The color code is composed of a number of permanently colored bands, each of which is a different color. The color graduation system has been designed so that each full turn of the screw exposes another color. In addition, the screw is graduated numerically so that the valve can be set on Red 5, Blue 6, etc. Many other new features have been incorporated into the Colorflow valve. A guided poppet stem eliminates poppet "cocking" and insures accurate seating; a positive needle stop prevents the needle from being backed completely out; a poppet stop insures against spring damage; a locking set screw eliminates tampering by unauthorized personnel.

MINIATURIZED LUBRICATING SYSTEM INTRODUCED



A new miniaturized injector system for automatic lubrication of production machinery has been introduced. Called the Micro-Measure System, it is said to pre-measure and inject fluid lubricants to "millionths of an ounce" in automatic cycles as often as every minute. An automatically controlled, air-operated pump supplies refinery-pure lubricant to small, economical injectors with micro-meter adjustment—at a predetermined rate, in quantities as small as 1/135 of a drop (200 millionths of an ounce). The system is said to maintain a constant, uniform oil film on all bearing surfaces with no overflow and no dripping. The manufacturer claims it has been successfully applied in the textile processing, metalworking, packaging and other industries, at very clow cost. Further information is contained in Micro-Measure Bulletin 816, available upon request from Lincoln Engineering Co., Industrial Div., 4010 Goodfellow Blvd., St. Louis 20, Mo.

TAPE DESIGNED TO SEAL

A chemically-inert tape designed to seal and to permanently lubricate pipe joints, has been announced by Minnesota Mining and Manufacturing Co. (3M), Dept. J9-210, 900 Bush Ave., St. Paul 6, Minn. Called "Scotch" brand Pipe Sealant Tape, No. 547, this unfused film tape, available in three and four mil

(Cont. on p. 274)

Under wet conditions...
Greases made with

BARAGEL*

— stand up longer!

BARAGEL greases do stand up longer... under wet conditions... such as exist on ore flotation equipment.

BAROID CHEMICALS, INC.

A SUBSIDIARY OF NATIONAL LEAD COMPANY

1809 SOUTH COAST BLDG. HOUSTON 2, TEXAS

5982

*BARAGEL is a registered trademark of National Lead Company for organic ammonium montmorillonites.

TUTHILL automatic reversing pumps

- Positive reversing action
- Require no valves
- Port positions remain constant

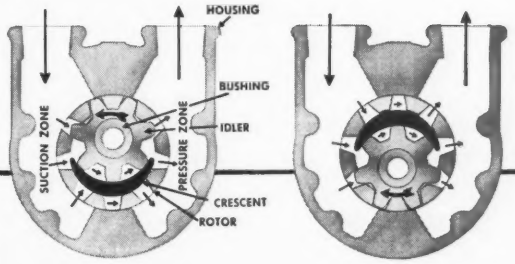
The model RCK above is typical of Tuthill's complete line of automatic reversing pumps . . . which use the time tested operating principle at the right to provide instantaneous, positive reversing action without the use of valves. The port positions remain constant regardless of the direction of shaft rotation. And all pumps provide uniformly high efficiency in both flow directions.

The automatic reversing design was developed by Tuthill for applications where the pump must be driven from a reversing shaft, or where machinery must be shipped without knowing the ultimate direction of the driving unit. These pumps have been enthusiastically accepted by designers and have proven their dependability in thousands of demanding applications such as large air compressors and machine tools.

375 Models

A complete selection of 375 models is provided with capacities from ⅓ to 200 gpm; for pressures to 400 psi; and speeds to 1800 rpm. Included are a complete assortment of stripped models specially developed for incorporation into manufactured products.

A 12-page catalog, No. 105, gives complete information on all Tuthill automatic reversing pumps. Write today for your copy. Or, if you desire, send drawings so that Tuthill's engineers can show you how the Model R reversing pump can be built directly into your product.



COUNTER-CLOCKWISE ROTATION

CLOCKWISE ROTATION

THE PUMPING PRINCIPLE

Tuthill automatic reversing pumps are based on the use of a rotor, idler gear and a crescent shaped partition which is integral with a moving part called the Idler Carrier.

Figure 1 shows how power is applied in counter-clockwise rotation to the rotor and transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the inside diameter of the rotor is sealed by the crescent. When the pump is started there is an increase in volume as the teeth come out of mesh. This creates a partial vacuum, drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and rotor and is carried past the crescent partition to the pressure side of the pump. When the teeth mesh on the pressure side, the liquid is forced from the spaces and out through the discharge port.

When the shaft rotation changes from counter-clockwise to clockwise, the idler carrier (including the idler gear and crescent) automatically rotates 180° through the suction zone to the position shown in Figure 2 which *changes the direction of flow within the pump* without changing port positions. The idler carrier rotates in a cover casting fitted with stops so that the crescent can rotate only 180°—always through the suction zone. Upon resumption of counter-clockwise rotation, the crescent will swing back to the original position in Figure 1.

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From ⅓ to 200 GPM; for Pressures to 1500 PSI; speeds to 3600 RPM.

PUMPS FOR YOUR PURPOSE

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NFPA NATIONAL FLUID POWER ASSOCIATION

ASLE Publications

Interpreting Service Damage In Rolling Type Bearings

A manual on ball and roller bearing damage which includes drawings, tables, and 74 photographs for aiding in the classification and identification of the causes of many of the common types of bearing damage. $1.00 per copy, $2.00 Foreign.

Lubrication Engineering Decennial Index

Subject & Author Indexes listing the papers published in **"Lubrication Engineering,"** Journal of the American Society of Lubrication Engineers, in Volumes 1 thru 10 (1945 thru 1954). 50¢ per copy, $1.00 Foreign.

Petroleum-Type Hydraulic Fluids

Second in the series of ASLE monographs, covering Hydraulic Oil Specifications & Service Properties, Viscosity, Viscosity Index, Demulsibility, Oxidation Stability, Lubricating Value, Rust & Corrosion Preventive Qualities. $1.00 per copy, $2.00 Foreign.

Industrial Dermatoses—Protection, Prevention, and Treatment

Eight experts in the field of industrial dermatitis assemble for the first time their experience and investigations in an ASLE-sponsored effort to curb these costly diseases. The experts examine the use and handling of cutting oils, lubricants, and solvents. Protective measures such as ointments, housekeeping, and preventing bacterial decomposition are discussed. $1.00 per copy, $2.00 Foreign.

A Survey of Journal Bearing Literature

By Professor D. D. Fuller, Columbia Univ.

The results of an eight-year cooperative journal bearing research project sponsored by the ASLE and financed by industry. Over 2500 literature references have been screened and evaluated. The resulting summaries of the original articles and books includes all the pertinent information to support the 33 chapters dealing with bearing design, manufacture, and effective use of journal bearings. $15.00 per copy.

Write:
American Society of Lubrication Engineers
5 N. Wabash Ave., Chicago 2, Ill.

PERSONALS

(Cont. from p. 267)

Marion M. Caskie, John A. Robertshaw, and Basil Horsfield.

A. J. McDonald, Jr. was appointed sales manager of Welders' Supply Company.

Mr. Arthur S. Randak, Sinclair Refining Co. died May 5, (member New York Section ASLE)

Also died; **Mr. John B. Calkin,** president of Calkin and Bayley, Inc., (member New York Section ASLE)

SECTION NEWS

Detroit—A conference on "Planned Lubrication as a Profitable Investment" was presented by Wayne State University and University of Michigan with the Detroit section as one of the sponsors. . . . **Pittsburgh**—At the May 14 meeting George L. Duke, Westinghouse Electric Corp. spoke on his paper "The Right Lubricant at the Right Price." . . . **Rochester**—Members enjoyed an informal picnic with wives and friends June 17 . . . **Twin Cities**—Dinner, dancing, and a floor show entertained Society members at June 4 social meeting. At the regular meeting, April 30, Kenneth D. Relyea of the Texas Research Center spoke on "Railway Diesel Lubrication."

NEW PRODUCTS

(Cont. from p. 271)

calipers, can be applied in seconds and conforms to all types of pipe threads and fittings, according to the 3M company. Made with a "Teflon" TFE-fluorocarbon resin, it can withstand processing temperatures from the liquid-oxygen range through that of super-heated steam, 3M said. It is not affected by oil traces or other lubricants in the steam line. Although non-adhesive, the tape is sufficiently cohesive to stick to its own glossy surface, 3M said. The tape's easy application eliminates the need for brushing messy dope solutions on pipe fittings. It can be applied by one person and a single wrapping affords full protection. Excess tape can be torn off easily. The tape's anti-sticking characteristics lubricate joints so they can be loosened and detached years after the threads are taped, 3M declared.

This white, pliable tape is available in convenient 36 yard rolls in ¼ in. to 8 in. widths.

"Since Cities Service Pacemaker 300 T-Injection molders operating perfectly."

Daniel A. Goetz, President and Charles R. Goetz, Dan's twin brother and Vice President of Stylette Plastics, agree on the value of a superior hydraulic oil. As Dan Goetz says, "we produce millions of 'giveaway' items every year. These items must be inexpensive . . . and to obtain the lowest cost possible we must produce in quantity and without expensive down-time on our injection molding machines. We had previously had trouble with our hydraulic oil and I think it was primarily due to the heat involved. We called in the Cities Service Lubrication Engineer and he switched us to Pacemaker 300 T. **Since using Pacemaker 300 T, our six injection molders have been operating perfectly."**

Pacemaker T is a premium hydraulic oil with excellent heat resistant properties and suitable for every type of hydraulic system. These oils have high viscosity index to minimize viscosity change with changing temperatures.

They are also fortified to resist oxidation and to give maximum protection against corrosion and rusting.

Contact your nearby Cities Service office for an experienced Lubrication Engineer to show you what advantages Pacemaker T can offer in your operation . . . or for further information, write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

The Goetz Twins, owners of Stylette Plastics went into the plastics business in Pittsburgh in 1952 on the recommendation of their professor at Duquesne University. They started with $1,500 and bought a nine ounce injection molding machine to make plastic tile.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

DIG INTO YOUR GREASE!

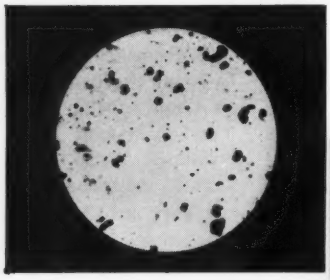
. . . you'll find you get greater MoS_2 coverage per dollar and a more uniform blend by adding Acheson dag® 208

Unless you look carefully, you may find it difficult to distinguish between greases made with different molybdenum disulfide additives. They may appear alike . . . even feel the same . . . but that's where the similarity stops. By actual photomicrographic comparison, the finer particles in 'dag' Dispersion 208 are your assurance of greater coverage . . . at no increase in solids content. Or, looking at it another way, equal coverage and greater effectiveness can be obtained at a much lower solids content, thus extending the range of application to even closer-tolerance mechanisms.

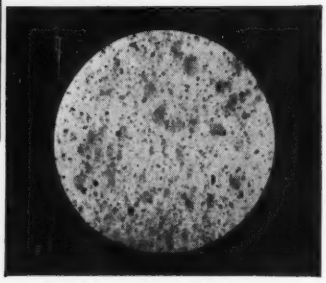
Because of the ease with which 'dag' 208 can be handled, measured and blended, there are additional savings in compounding time and labor. This stable dispersion assures the blender and the end-user of a consistently uniform grease.

If you are one of the many progressive *marketers* now considering adding a moly-fortified grease to your line, we urge you to evaluate 'dag' 208 today! If you are one of the many current *users* of moly-fortified lubricants, be sure to specify that the ones you purchase are formulated with Acheson's moly dispersions. Send in the coupon for a complimentary sample.

The same advantages of molybdenum disulfide can be incorporated in petroleum oils and polyalkylene glycol fluids. 'dag' Dispersions 200 and 207 are the finest colloidal concentrates available for these applications. Experimental samples may be obtained upon request.



Shown here is a dramatic comparison of particle sizes. Both Acheson's new dispersion, 'dag' 208, (below) and the finest commercially available molybdenum disulfide powder (at left), have been magnified 300 times.



Tests prove that the predominantly finer particles in 'dag' 208 (at right) provide 80% greater hiding power . . . more coverage per dollar.

Acheson Colloids Company

Dept. LE-79, Port Huron, Michigan

Please send me free of charge your trial sample of

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Lube Lines

by A. F. Brewer*

ACIDITY

When management is considering the effects of acids on lubrication it is important to remember that there are two basic sources of these potentially harmful chemicals:

1. The acid compounds which are naturally present in crude petroleum in the form of organic or mineral acids.
2. Those acids which may be present from some external source such as acidic fumes, sulfuric residues from refinery treatment, or as a result of the process of fermentation or oxidation.

The nature as well as the concentration of the acid can have a decided effect upon the degree of harmfulness. Organic acids in petroleum base lubricants being weaker are far less serious than mineral acids. Even so, the petroleum acid characteristics of petroleum lubricants must be known wherever corrosion may be a factor, as in anti-friction bearing service. Acidity which develops in service can promote serious impairment of effective lubrication when sludge, gum and corrosion deposits result. Acids such as malic, citric, tartaric and acetic which are present in fruit and vegetable juices in their natural state also are generally weak, but as such they often can be more corrosive to certain metals and bearing materials than when more highly concentrated.

The process of fermentation relates directly to the potential detrimental effect. For example acetic acid sometimes may exert a decomposing effect upon certain types of soaps which are used in grease manufacture. It becomes the responsibility of the petroleum chemist to consider the service for which the grease is intended and to select his soap accordingly. The lubrication engineer in turn should realize that this potential decomposing effect of certain acids could result in an unstable mixture of fatty acid and mineral oil which might seriously impair effective lubrication should bearing construction permit this oil to leak out or run off prematurely.

OXIDATION, SLUDGE, RUST, CORROSION

Aside from the detrimental effects of certain acids upon certain types of lubricants, there are the questions of oxidation and sludge development, rust formation and corrosion to be considered. Acidity in a turbine oil or a petroleum base hydraulic fluid can promote oxidation in service with subsequent formation of sludge; hence the use of the neutralization value as an indication of rate of oxidation in service. Under favorable conditions oxidation products in some used crankcase oils may include volatile acids which could have a corrosive effect upon certain bearing materials.

Where acetic acid may be present to contaminate the lubricant it is important to remember that this acid especially in concentrated form, being somewhat of a solvent or refining agent for petroleum oils, may exert a sort of refining effect upon a straight mineral oil or the petroleum component of a grease, to produce more or less sludge, especially if the oil has not been thoroughly refined in the first place. It is obvious that in certain types of lubricating systems sludge formation can be highly objectionable due to the possibility of clogging and interference with complete circulation of the lubricant. In others, sludge formation may be the forerunner of gum formation and lacquering.

Rusting and corrosion are more or less related, in that both can alter the surfaces of the contacting elements. While rusting is confined to the iron and steel parts of the assembly, corrosion can develop either there or on the bearing metal surfaces. In food handling the acids of fermentation can be particularly objectionable, hence the advisability of insisting on highly refined petroleum ingredients. By using petroleum oils in grease manufacture which will be as resistant as possible to the solvent action of acetic acid the stability of the resultant greases is more positively assured with greater resistance to penetration of acid to the metallic parts being lubricated. In the automotive engine the possible corrosive effect of certain oils with preferential removal of lead from copper-lead bearings could seriously impair the load-carrying ability of the bearing.

RESISTANCE TO CHEMICAL ACTION

As one of the primary functions of a lubricant is to prevent any type of acidity from directly contacting the operating mechanisms, the objective is most dependably attained if the lubricant is so refined and fortified by suitable additives as to render it as resistant as possible to chemical reaction. Actually this means that the lubricant must be possessed of maximum chemical stability. The laboratory can follow this characteristic by testing periodically for increase in the acid content of an oil. Rapid increase in the neutralization value indicates that oxidation is progressing to cause active formation of acids. This is a warning that serious consideration should be given to changing the oil in the system; it is especially important in paper mill, steel mill, turbine and hydraulic service where a considerable volume of oil is being circulated and where bearing renewal due to impaired

(Cont. on p. 300)

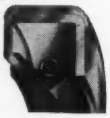
* Consultant and author "Basic Lubrication Practice."

NATIONAL OIL SEAL LOGBOOK

Oil Seal Selector Chart

The data given below indicate, for most common applications, the type of oil seal that will operate best under given conditions. Where one or more parameters are extreme, modified or special seals may be required. For engineering help or availability details, call the nearest National Seal Engineer. Look under Oil Seals, in the Yellow Pages.

50,000 series
Micro-Torc
Leather



450,000 series
Syntech
Synthetic

410,000 series
Syntech
Synthetic

MATERIAL SEALED	Mineral base oils and greases are most common materials. Availability of lubricant, criticalness of service, and cleanliness strongly influence construction choice. National Micro-Torc leather seals are recommended for grease and oil applications and particularly where semi-starved lubricant conditions may exist. For oil and fluid "zero leakage" service Syntech seals are normally considered. For applications involving both "zero leakage" and heavy dirt conditions, the user may wish to consider dual lip Syntech seals.			
SHAFT SPEED	Prime factor in seal selection. Governs all other factors. Shown in FEET PER MINUTE AS SLOW, MODERATE, HIGH.			
FPM	Slow	0 to 800	0 to 1000	0 to 1000
	Moderate	800 to 1500	1000 to 2000	1000 to 2000
	High	1500 to 2000	2000 to 3000	2000 to 3000
TEMPERATURE	Limits shown are points where sealing material or medium sealed becomes ineffective. For sealing under extreme temperature conditions, special compounds can be employed.			
LIMITS °F.	Continuous	−65° +200°	−65° +225°	−65° +225°
	Intermittent	−65° +225°	−60° +250°	−60° +250°
PRESSURE	Conventional oil seals are not pressure seals. Where pressures above those shown exist, special seals should be employed or pressure against sealing lip relieved.			
MAXIMUM PSI	Slow	15	10	10
	Moderate	10	7	7
	High	5	5	5
SHAFT FINISH	Fineness and type of finish, direction and spiral of finishing marks and leads as well as RMS value affect sealing. Polished or ground finishes with concentric finish marks are preferred.			
MAXIMUM MICRO INCHES	Slow	25	25	25
	Moderate	20	20	20
	High	20	20	20
SHAFT HARDNESS	Although shafts as soft as cold rolled steel can be sealed successfully, hardness of C20 Rockwell or greater is preferred. Fluid starvation, abrasives and high surface speeds require hard shafts.			
SUGGESTED ROCKWELL	Abrasives	above C-45	above C-45	above C-45
	No abrasives	above B-80	above B-80	above B-80
SHAFT TO BORE MISALIGNMENT	Fixed misalignment of center of shaft rotation with bore center. Concentrates wear at one side of seal. Becomes more severe as speed increases.			
TOTAL INDICATOR	Slow	.010	.015	.015
	Moderate	.005	.010	.010
	High	.005	.010	.010
SHAFT RUN-OUT	Oscillating non-concentricity between shaft and bore centers (also eccentricity or shaft whip). Run-out should be kept to absolute minimum; creates difficult sealing problem.			
TOTAL INDICATOR RPM	0-800	.010	.025	.025
	800-2200	.005	.020	.020
	2200-4200	.003	.015	.015

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California
Van Wert, Ohio

Vol. 15, No. 7

Lubrication Engineering

what price—recognition?

Costs keep rising—the purchasing power of the dollar declines—everybody asks (and generally gets) more for identical services they were providing a few years back at a lower price—and many of us wonder when or where the vicious spiral will stop.

This problem is not peculiar to profit seeking groups, but is related as well to not-for-profit organizations. As a matter of fact, it can be applied with even a greater force, since not-for-profit groups do not have a margin of profit to fall back on. Current operating expenses must be paid out of current income. It's true that Reserve Funds do permit a certain degree of flexibility, but every dip into Reserve Funds must be carefully evaluated to measure its real worth.

While on the subject of income, let us examine the sources of revenue which keep our Society in business. The basic one is membership dues. Our annual budget anticipates that 40% of our revenue is realized from this source. The balance is made up from advertising (30%), annual lubrication exhibit (10%), sales of publications (10%) and the balance from interest and miscellaneous items. This so-called "by-product" revenue represents better than half of the total revenue available to the Society.

By comparison with groups engaged in the same line of activity, this is high or low, depending on a number of factors. The total membership of the group is one of these factors. Obviously, if we had 30,000 members instead of 3,000 we could command a higher page rate for advertising and substantially increase our income from this source. Then too, the larger circulation would permit us to obtain advertisers who do not at present use space in our journal. The same logic can well be applied to our annual lubrication exhibit and sale of publications.

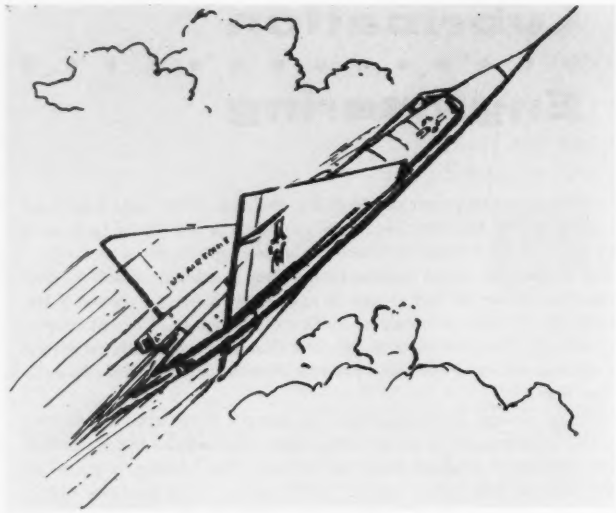
The expense side of the ledger does not present a very rosy picture—for the problem of rising costs has also hit ASLE. While our revenue figures remain relatively static —our disbursement figures are quite dynamic. Particularly in view of the fact that we are constantly striving to offer more and better service to members and industry. This, indeed, becomes a real problem. We, as a Society, cannot sit still. We must embark on new programs and activities—and this costs money. Money which may not be immediately returned to us, for it is an investment in ASLE's future. Two outstanding examples readily come to mind—"A Survey of Journal Bearing Literature" and "ASLE Transactions." The technical information contained in these volumes may have never been published if it had not been undertaken by ASLE. These are "firsts" and with these "firsts" comes recognition and prestige—two precious items if we are to continue as a leader in the field of lubrication. Neither of these undertakings will directly pay for themselves in a year—or possibly never—but indirectly they may make the real difference between being respected, sought, or tolerated.

Another example—our plans for LUBRICATION ENGINEERING. Our efforts to better serve the members is being continued with the editorial expansion of our journal. The need for more appealing articles, original feature type presentations, has been recognized for some time. Lack of funds has been and remains a problem. The Board of Directors has squarely faced this dilemma by authorizing the hiring of an engineering writer to handle assignments of this nature. This decision will have far-reaching effects on the Society. By broadening the editorial coverage of our journal, we hope to obtain additional Society members, resulting in increased circulation and in turn greater recognition. This would permit an increase in advertising page rates and provide more funds for better programs and means to serve Society members in a better manner.

Let us refer to our time-worn cliché—"this costs money." So does food, clothing, housing, transportation, entertainment, smoking, etc.! But without technical competence a lesser number or smaller variety of these things can be had. This is for sure. By authorizing a dues increase, effective January, 1960, from $15 to $20 per year, the Board of Directors is looking at ASLE's future! This authorized increase in dues is a small price for recognition, technical competence and our Society's future.

A. B. Wilder,
President

Some Considerations Relating to Lubrication of



Aircraft Turbine Engines

by Alfred B. Two

Motor Oils Refining Company, Lyons, Illinois

The rapidly changing problems encountered in the lubrication of aircraft engines have necessitated extensive research and development in this field. The present paper describes the requirements of present day aircraft engines and discusses the lubricants which are currently being used.

The 50th anniversary of the Wright Brothers' flight was celebrated not too long ago. The engine used for power in the airplane was built to produce nine horsepower and actually delivered 12 horsepower. Since this first powered flight, there has been a steady development in both the reciprocating engine and the aircraft gas turbine, the latter taking over as the key source of power for military aircraft around 1946. The thrust horsepower has now reached a value of about 16,000. It is evident that the reciprocating engine has reached its limit of economical output in those models now currently being used.

The driving force behind this increase in engine power is the desire for greatly increased speeds, particularly in military interceptor aircraft. In 1909, the official international speed record was 46.8 mph.

It may be of interest to review briefly the basic principle of jet propulsion. The piston type engine operates on the principle of constant volume, which is known as the Otto Cycle. Jet engines, by comparison employ constant pressure, which is referred to as the Brayton Cycle. Jet engines operate on the fundamental reaction principle that a force is required to counterbalance a change in momentum. Momentum is the product of mass and acceleration. The net or useful thrust of a jet engine equals its mass flow of air multiplied by the amount that the propulsion jet velocity exceeds the aircraft speed. At an aircraft speed of 375 mph one pound of thrust is equivalent to one brake horsepower, and equivalent horsepower varies directly with the speed so that at 750 mph one pound of thrust is equivalent to two horsepower. Contrary to a common misconception, jet thrust does not depend in any way upon the pushing of the exhaust gases against air. On the contrary, the principle applies equally well in a vacuum.

Two of the main concerns in increasing speeds of flight are the great increase in aircraft skin temperature, and the temperature increase of air entering the compressor of the engine because of adiabatic compression, as shown in Fig. 1. The possibility of producing aircraft and guided missiles for operation at Mach 2.5 is being actively investigated at this time. Flight at this speed can mean compressor inlet temperatures at altitude in the neighborhood of 500F. This rise in temperature is passed along through the compressor section and represents problems to both the metallurgist and the person in charge of lubrication system design for the engine.

Even under the best of present operating conditions the aircraft gas turbine is difficult to lubricate. Flights are now being made at altitudes of 50,000 ft which means both low ambient temperatures and low atmospheric pressures, as graphically illustrated by Fig. 2. The ambient temperature must be considered as one of the limits of operation since it is common practice in multiple engine installations to cruise with

Presented before the Detroit and Twin Cities sections of the American Society of Lubrication Engineers.

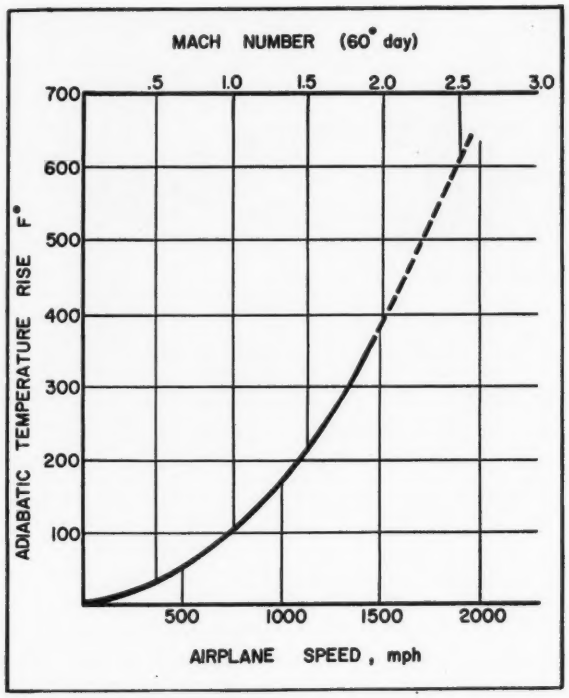


Fig. 1. Adiabatic temperature rise vs true airplane speed.

some engines off. If the oil solidifies or thickens excessively, restarting of the engine may be impossible. Most lubricating oil tank breathers are closed automatically at an altitude of 20,000 to 30,000 feet. However, even at this altitude the absolute pressure is about half that at sea level and will obviously affect the consumption of engine oil. The consumption factor multiplies in importance as aircraft range and engine fuel economy increase.

As in all types of power plants, bearings and gears must be cooled and lubricated by the circulated oil. The unique part of the problem of lubricating a jet engine is that many of these parts are located next to burners and turbine wheels where temperatures can be as high as 1600F, while external temperatures are below —65F, as illustrated by Fig. 3.

It is obvious, then, that the conditions under which the lubricant must work are quite different than those experienced in the reciprocating engine or in ground equipment. As shown by Table 1 the tempera-

TABLE 1. Operating Conditions

PART	TEMPERATURE RANGE	SPEED RPM	LOADS
BEARINGS			
Plain	—65 to 300F	6,000-12,000	Light
Anti-friction	—65 to 450F	6,000-20,000	Light
GEARS	—65 to 400F	1,000-20,000	Medium to Heavy

tures at which the lubricant must satisfactorily operate for both bearing and gear lubrication range from —65F and below to something in excess of 450F. Also, bearing and gear speeds are high and vary considerably with engine design. Bearing loads are generally light and gear loads vary, being the lightest on the turbo jet engine accessory gears and the heaviest on the turbo-prop nose gears. With this background of operating conditions, it should be possible to define in general terms what qualities are required in the lubricant to be used in these engines.

QUALITY REQUIREMENTS

It is desirable to have one lubricant having the requirements shown in Table 2 which will satisfy all of these engines, both turbo-prop and turbo-jet. It is necessary, therefore, to satisfy the load carrying requirements of the turbo-prop engines which are the critical group in this respect. It has been found in most applications that the load carrying ability of a Grade 1100 aviation engine oil which is 100 sus viscosity at 210F is satisfactory for this application. Therefore, it is required to have a product which is equivalent, if possible to Grade 1100 oil. If only turbo-jet accessory gears are to be considered, 45-50 per cent of the load carrying capacity of Grade 1100 should suffice.

TABLE 2. Quality Requirements (Aviation Gas Turbine Oils)

PERFORMANCE REQUIREMENT	DESIRED OIL PROPERTY
Lubricate Heavily Loaded Gears and Bearings	45-100% of Load Carrying Ability of Grade 1100
Low Consumption	Low Evaporation Rate Non-foaming Compatible with Sealing Materials
Non-corrosive Non-deposit-forming	Thermally Stable Oxidation Stable } at 350-450F. Non-corrosive
Low-temperature Pumpability	Viscosity at Min. Starting Temp. 5,000-20,000 cs

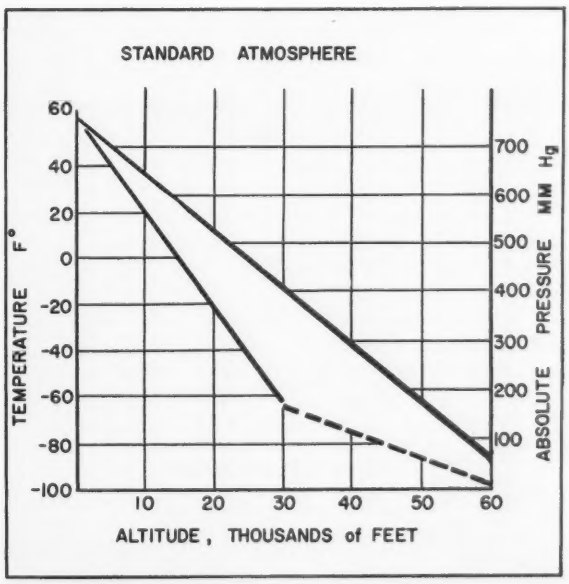


Fig. 2. Relationship of altitude, temperature and pressure.

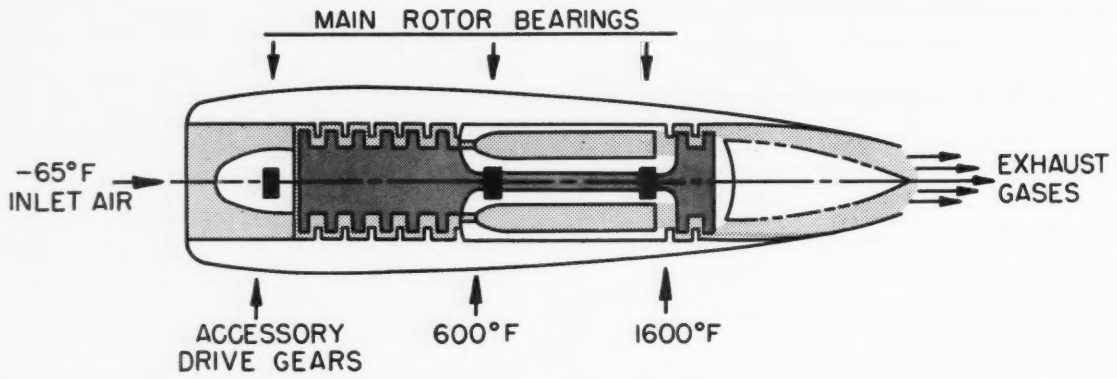


Fig. 3. Turbine engine temperatures.

Because of the altitude at which the aircraft are to operate and the resultant low atmospheric pressure around the aircraft along with the high oil temperatures, it is very important to have a low volatility product to prevent losses by evaporation. In addition, the oil should not foam and should be essentially non-destructive to elastomers used as seals in the lubricating system. All of these qualities are necessary if oil consumption is to be held to a minimum.

Many metals are involved in the construction of a satisfactory aircraft gas turbine engine, and all must be considered in developing the lubricant because of possible corrosive effects of the lubricant. Also, with high speed antifriction bearings excessive carbon or varnish deposits on the bearings cannot be tolerated. It is, therefore, necessary that the compound be thermally and oxidation stable, and non-corrosive at the temperatures of operation.

The effect of ambient temperature on ability to restart engines at altitude has been mentioned. In addition, the problem of starting engines on the ground in arctic regions is of prime importance if interception of enemy bombers is to be effective. Therefore, a satisfactorily low viscosity for engine starting at low temperatures and a correspondingly low pour point are required. Minimum viscosities for satisfactory starting have been cited by various authorities and range from 5,000 to 20,000 cs, since there is a considerable variation in the pumps and piping in the lubrication systems on various engines and aircraft. What is desired is to take care of the worst condition so far as the starting problem is concerned which would mean a maximum viscosity of 5,000 cs at the lowest operating temperature.

Due to the problems inherent to selecting the proper lubricant for an application, it is obvious that the quality requirements are fairly difficult to meet. Consideration is given only to the materials which are available as possible solutions to the problem.

CHOICE OF LUBRICANT

Both Grade 1100 engine oil and Grade 1010 engine oil have been rated for load carrying, viscosity-temperature relationship, volatility, high temperature oxidation stability and cost in Table 3. The ratings are relative and since it has been established that Grade 1100 oil would be satisfactory on load carrying ability, therefore it is necessary to determine how these other materials in the classification of synthetics rate against this product. The list of synthetic materials is by no means complete and of course there are hundreds of compounds and thousands of combinations possible under each of the classifications. Selected from the list of synthetic materials are the diesters, silicate esters, and phosphate esters for load carrying qualities. In considering the consumption to be expected with these products, an examination of volatility ratings disqualifies the polyglycol ethers. The high temperature oxidation stability ratings give an indication of the deposit forming tendencies of the fluids considered. Therefore, the silicate esters and the polyglycol ethers are excluded.

Low temperature starting is rated in table 3 by viscosity-temperature relationship. In the synthetic group, the phosphate esters rate low and must therefore be excluded.

The important task is to get something to operate satisfactorily regardless of initial cost. If the lubricant does its job properly, its life and volatility will be such that the utility of a given charge of lubricant is considerably greater than experienced with the petroleum products such as Grade 1010 and relative maintenance costs can probably be made equivalent or even less with the synthetics. This has been shown to be the case in several flight test programs conducted by the military.

In general, then, it can be stated that the diesters are the best class of products to investigate since they are rated "good" on all four qualities that are being considered, as indicated in Table 3. As mentioned previously, there are hundreds and even thousands of compounds that are of possible use. The screening program in the laboratory involves many tests of many compounds and, in the case of the development of a satisfactory MIL-L-7808C, Amendment-1 product, this laboratory work required several years of intensive research both here and in Great Britain. Specification MIL-L-7808C Amendment-1 type Oils currently may and for some time probably will consist of the following materials:

Base Stock: A diester made from branched chain

TABLE 3. CHOICE OF LUBRICANT

	LOAD CARRYING	VOLATILITY	HIGH-TEMP. OXIDATION STABILITY	VISCOSITY-TEMPERATURE	COST $/GAL.
PETROLEUM					
Grade 1100	G	F	P	F	.75
Grade 1010	P	P	P	F	.55
SYNTHETICS					
Diesters	G	G	G	G	$ 5-10
Silicones	P	G	E	E	$30-40
Silicate Esters	G	G	P	E	$10-12
Polyglycol Ethers	F	F	F	G	$ 2- 6
Phosphate Esters	G	G	G	F	$ 4-12

E—excellent F—fair
G—good P—poor

alcohols and straight chain aliphatic dibasic acids as exemplified by di-2-ethyl hexyl sebacate.

Antiwear Additive: Tricresyl phosphate or other proprietary additives.

Oxidation Inhibitor: Phenolthiazine.

Antifoam Agent: Silicone or a similar proprietary additive.

Viscosity Index Improver: Proprietary additives.

MIL-L-7808C, AMENDMENT-1 OIL COMPARED WITH QUALITY REQUIREMENTS

Considering the quality requirements that have been set forth for this lubricant, it is now well to determine the progress made in development. Results are shown in Table 4. Load carrying ability is now

TABLE 4. MIL-L-7808C. AMENDMENT-1 LUBRICANT

	REQUIREMENTS	INSPECTIONS
Viscosity @ 210F, cs	3.0 min	3.6
@ −65F, cs	13,000 max	12,600
Flash Point, F	350 min	430
Pour Point, F	−75 max	−90
Ryder Gear Test, lb/in	1,700 min	2,000
Panel Coking @ 600F, mg	100 max	59
Corrosion—Copper @ 450F, mg/sq in	3.0 max	1.6
—Silver @ 450F, mg/sq in	3.0 max	0.7
Oxidation and Corrosion Stability @ 347F		
Weight Change, mg/sq cm		
steel, silver, aluminum, magnesium	±0.2 max	Complies
copper	±0.4 max	Complies
Total Acid No. Increase	2.0 max	0.8
Viscosity Change @ 100F, %	−5 to +15	+2.0

measured by high speed gear rigs both in this country and in Great Britain. The test unit specified in the military specification is the Ryder Gear Lubricant Tester. This is a four square rig which operates at 10,000 rpm, and an oil temperature of 165F has been selected as the optimum temperature for oil evaluation. Gears are run under increasing loads until 22½ per cent of the gear tooth area is scuffed. The gear load is reported in lbs/in. of tooth width, Grade 1100 oil gives an average value of 3200 lbs/in. Grade 1010 engine oil gives a value of 180 lbs/in. The MIL-L-7808C, Amendment-1 product which is presently approved gives an average rating of 2000 lbs/in. of tooth width. It should be pointed out that a similar product which is used in Europe and to a limited degree in this country does give the equivalent of 100 per cent of the load carrying value of Grade 1100 oil but is of higher viscosity since the British require operation only to −40F whereas the United States requires operation to −65F.

The next consideration is the volatility of the product. This can best be illustrated by comparing the vapor pressure of a typical Grade 1010 oil with that of MIL-L-7808C, Amendment-1. At a temperature of 300F which is not unreasonable for bulk oil temperature in later models of turbo-jets, the synthetic product has a vapor pressure of 0.1 mm of mercury. The Grade 1010 has a value of 25 mm of mercury or over 200 times that of the synthetic oil. Or, expressing it in another way, if the bulk oil temperature is 450F, the boiling altitudes for Grade 1010 and the synthetic oil are about 47,000 ft and 78,000 ft respectively.

The next quality requirement which is listed is the oil's deposit forming tendency and its non-corrosiveness. Deposit forming tendency is measured by what is known as the panel coking test. In this test the oil is splashed against a heated aluminum plate by a metal shaft with wires attached in the form of bristles. The plate is heated to 600F by an electrical strip heater and the weight of coke formed on the panel is measured at the end of eight hours. The requirement of the specification is that there will be less than 80 mg of coke. The presently approved MIL-L-7808C, Amendment-1 oil averages about 10 mg.

The low temperature properties required are to some extent dependent upon the individual lubricating systems. Grade 1010 oil has been generally satisfactory from the standpoint of low temperature starting characteristics. If 5,000 centistokes is taken as the

minimum viscosity for proper low temperature operation, the synthetic oil shows nearly a 10F advantage over the mineral oil Grade 1010. If 20,000 centistokes is the limiting viscosity an even greater temperature difference exists in favor of this synthetic product, since the two viscosity-temperature lines diverge as viscosity increases from 400 centistokes. The pour point on both of these products is in the vicinity of −80 to −90F.

As has been previously noted the oil must properly lubricate the engine bearings at high speeds and relatively high temperatures. To prevent premature failure and obtain maximum life from these bearings, which are for the most part of the anti-friction type, extreme and diligent care must be exercised in the assembly of engines and their subsequent operation to keep them clean.

The ideal arrangement is to have the assembly plant air-conditioned. All doors, windows and other openings should be kept closed and plant air, cleaned prior to being handled, pumped into the building. With this system a positive air pressure slightly higher than that of atmospheric air or adjoining buildings is maintained, thereby preventing dust laden air from leaking into the assembly building. In some assembly plants for aircraft engines periodic checks are made on the dirt fall-out in the air. A fall-out of 0.0025 gm/sq ft/48 hr is considered maximum for good operations.

If more than this is recorded, an investigation should be made so as to isolate the source and institute corrective action.

It has been found necessary to install full flow type filters for filtering the fluid used in flow checking engine sub-assemblies and also the solvent used for power cleaning. Also filters are generally used in the test cell oil systems when engines undergo break-in and check runs.

MIL-C-8188B CORROSION PREVENTIVE OIL

MIL-C-8188B specifies a corrosion preventive version of MIL-L-7808C Amendment-1. The only difference between the two grades of oil specified so far as requirements are concerned is that Grade B is inferior to Grade A regarding rubber swell. Grade B was established to allow the use of a more available base oil derived from petroleum in the less critical engines. Grade A is made from the same base materials as the MIL-L-7808C, Amendment-1 Oil. Since rubber swell is a function of temperature as well as oil composition, Grade A has been designated as the High Temperature Oil and Grade B as the Low Temperature Oil. Humidity cabinet life tests are also required as an indication of the corrosion preventive characteristics of both of these oils.

MATERIALS FOR USE WITH SYNTHETIC LUBRICANTS

One of the biggest problems in the application of synthetic lubricants has been to determine what materials can best be used with them. Materials that are affected by contact with MIL-L-7808C, Amendment-1 lubricant are shown in Table 5. The interaction of the oil and metals was the primary point of investigation

TABLE 5. MATERIALS AFFECTED BY CONTACT WITH MIL-L-7808C AMENDMENT-1 LUBRICANT

Metals	*Plastics*
Copper	Thermo-plastic
Bronze	Thermo-setting
Lead	
Cadmium Plate	*Elastomers*
Magnesium	Natural Rubber
Silver	Neoprene
Aluminum	Thiokol
Steel	Perbunan
	Butyl
Paints	
People	
External Contact	
Inhalation	

since it was believed that such things as plastics, elastomers and paints could be compounded to incorporate the necessary resistance.

Of the metals which the oil might contact, cadmium plate has shown the least resistance. In many cases this is believed to be due to the inadequacies of the cadmium plating job itself rather than a corrosive action of the oil since similar difficulties have been encountered with mineral oils. It is necessary that cadmium plate be deleted from all applications where contact with synthetic oils is probable. Of the more common metals, copper is probably the next least resistant to attack by oxidation products formed from the synthetic oils. This is indicated by the specification requirements which give a plus or minus 0.4 mg/sq cm allowable limit in the oxidation-corrosion test weight loss for copper, whereas aluminum, magnesium, steel, and silver plate can only show plus or minus 0.2 mg/sq cm in the same test. It is suggested that all copper or copper containing alloys be deleted as far as possible because of this corrosive effect as well as the catalytic effect of copper on oil oxidation. In anti-friction bearing applications, plating of the bronze retainers with silver or lead has accomplished this end. Ordinary steel alloys are entirely satisfactory for fabricating handling and storage equipment as are the more costly materials nickel, monel and stainless steel. Zinc falls in much the same category as copper as described above, therefore, galvanized equipment cannot be incorporated in the oil system.

With respect to plastics, there is one general rule which can be expressed. The thermo-setting type plastics are more resistant to softening action than are the thermo-plastic.

The problem of proper materials for use as oil seals where vibration is encountered has been a very bothersome one. In fact, until this problem is solved by either the exclusion of elastomers entirely or the compounding of elastomers usable at temperatures equal to the highest oil temperatures which are possible with present engines, the development of both lubricants and engines of higher output is restricted. This problem has been presented to all of the major compounders of elastomers for the aircraft industry

and research has led to products which are greatly improved over those available at the end of World War II.

The solvent effect of these oils has been very evident on painted surfaces which generally become stripped of all signs of paint in a relatively short time following oil contact. Several paint manufacturers have studied this problem and have developed paints which appear to be very resistant to the oil.

TOXICITY

The last item on this list of materials, which should probably not be classed as a material at all, is people. There are many highly publicized rumors about the toxicity which is exhibited by synthetic lubricants which have gone around the country. One may be assured that with regard to external contact, there is no more problem with the synthetic oils than with light mineral oils or solvents. Some drying of the skin has been noted where personnel are in fairly continuous contact with the oil, and this has been attributed to a skin defatting procedure which can be counteracted quite satisfactorily by common personal hygiene methods and the application of skin creams.

The problem of inhalation of hot oil fumes and products of high temperature breakdown has become of importance because most of the aircraft utilize compressor bleed air for cabin pressurization and heating. This is the aspect of the toxicity problem which has been most highly publicized. Investigations by authorities in the field have shown that the effect of the fumes from MIL-L-7808C, Amendment-1 oil on animals is similar to that obtained with mineral oils under the same conditions. Investigation indicates that the level of toxicity in aircraft under the worst conditions is such that no permanent damage could possibly be done to personnel subjected to these fumes. In fact, the problem has been classed as one of nuisance rather than toxicity by many in the field. It is recommended that where possible the airframe industry utilize a two-stage type of operation for cabin pressurization, taking outside air into the cabin and using compressor bleed air as a power source only.

AMOUNT OF EXPERIENCE

Regardless of all the trials and tribulations attendant with the development and use of synthetic lubricants for the aircraft gas turbine, it is estimated that there are now several million hours of engine test stand and flight test experience on these products in the United States and Great Britain. The development of synthetic lubricants was one of the most important steps to bring about increased performance in these power plants because it allowed for higher operating temperatures and resultant thrust increases and operating economies. The lubricant has become the equivalent of a structural part of the engine.

The list of the aircraft which are using or will be using synthetic oils for power plant lubrication is now quite extensive, including at least 21 aircraft. It includes the B-52 bomber, which has been publicized as being the most important Strategic Air Command weapons, and the F-100 through F-105 fighters which have been listed as the intercepter planes upon which the air defense is to be based. To this list could be added most of the military aircraft now being built in the United Kingdom. Many of the most advanced commercial transports being manufactured in this country use synthetic engine lubricant.

FUTURE

The demand for Specification MIL-L-7808C, Amendment-1 Oil is expected to increase yearly.

The job is far from complete. If operating temperatures can be increased another 50F, or 100F today, the engine industry can take another step in increasing power output. Efforts in this direction have led to the development of several experimental oils which show considerable promise. However, it must be realized that the step from the laboratory bench tests to full-scale engine tests is the longest and most time consuming. It cannot be accurately predicted what these oils will do until they have been operated in the most critical of engines in existence. There will be required oils with higher gear loading capacities and better thermal stability certainly within two to five years and could be used today. Towards this end, the Air Force has issued Specification MIL-L-9236, establishing "prototype-target" requirements for an oil able to lubricate advanced gas turbine engines. Much work is being done towards obtaining the goal of a high performance-high temperature oil.

What the experience will be with these future oils is hard to predict, but it is safe to say the experience with Specification MIL-L-7808 oil is just the beginning, and the end of the experiences with synthetic oils is far in the nebulous future.

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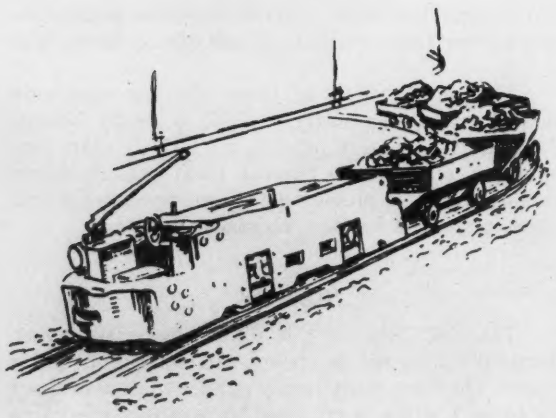
Centralized Lubrication in the Coal Mining Industry



by J. J. Slomer

Goodman Manufacturing Company, Chicago, Illinois

There are a number of physical hazards which make quite a problem for the handling and application of lubricants for mining equipment. The transportation of the lubricants, from the outside to the working face, must be done in a car used for hauling material to the outside. There is always the problem of handling and storage inside the mine. In mines there is a dust problem whereby all the equipment is covered completely with layers of dust which interferes with even seeing the equipment much less the lubrication points. It is also a difficult problem to dispense from a container to the lubricating hand gun or to a container on the machine so as to exclude the dirt.

The paper herein deals primarily with the economic aspects and advantages to be gained by centralized lubrication.

Although this paper has been primarily prepared to point out and illustrate the benefits to be derived from the application of modern power lubrication systems to coal mining machinery, it is only logical to consider first the economic condition and needs of the Coal Industry as a whole.

Most reliable and articulate authorities agree that the coal mining industry is comfortable today, with a fairly good financial return, and that there is an even better picture foreseen in the future.

Continued rise in demand is expected from present users, and there are some distinct possibilities of still more markets developing in the next five years—the manufacture of chemicals and carbon from coal, the coal-fired gas-turbine locomotive and, perhaps, motor fuel on a limited scale.

Consequently, the industry is spending heavily—at a rate of 50 to 60 cents per ton of output—for new properties and for equipment and facilities to modernize existing operations. This trend is expected to continue. Open-pit equipment has increased in size and in the electrical shovel category, a machine carrying a 70-cubic-yard dipper and costing around three million dollars has appeared.

Underground, there has been a steady rise in the installation of continuous mining equipment, with a large percentage accompanied by the extensible belt—the miner and belt together priced at about $200,000. There has also been a steady increase in the number of plants for processing fine coal and for reducing stream pollution.

In transportation and marketing, commercial operation of the overland coal pipeline is going to affect mine-to-market transportation costs—costs the industry wants to lower. There has also been a rise in the use of water transportation. Throughout the industry, major programs are underway to promote the use of coal by means of new engineering services and advertising.

THE YEARS AHEAD

There is a continuing demand for maintenance setups and personnel to match the equipment now being used. While new production methods and controls make it possible to get the necessary output from increasingly expensive facilities and labor, the industry needs more engineers and more skilled managers. Better market development and merchandising techniques are being sought, as well as more market research. With prices going up on everything the industry needs, it will examine more closely the chances of both remotely-controlled mining equipment and of underground pipelines as means to lower the mine-to-market costs.

From the foregoing, one cannot help but note two exceedingly important trends in the Coal Industry which show every promise of continuing: (1) mine operators are investing heavily for new equipment and facilities to modernize existing facilities; and (2) equipment being purchased is larger, more complex and more expensive, with a resultant and continuing need for more efficient maintenance methods and personnel to match the equipment.

This expressed need for more effective maintenance practices to protect costly equipment and, consequently, reduce operating expense, leads directly to

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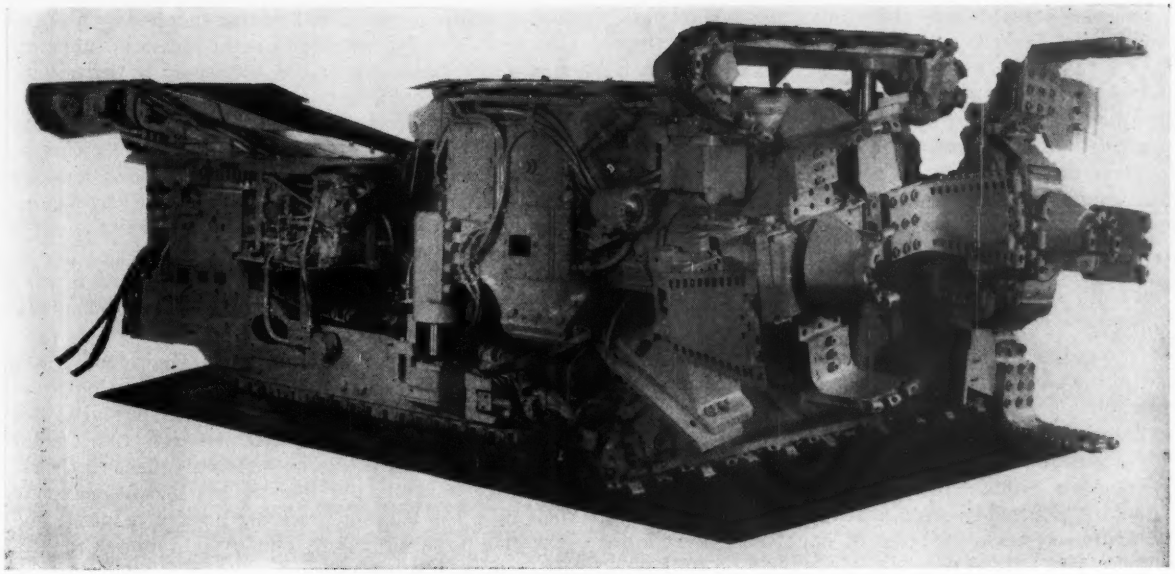

Fig. 1. Continuous coal borer with arm extended for cutting. Automatic lubricator is located on the right side of the machine.

the present subject . . . the benefits to be derived from modern automatic power lubrication systems.

It is a matter of established fact, documented by innumerable case histories, that automatic centralized power lubrication systems hit mine operating costs like a chain reaction. They cut down on the number of lubricants needed and the total consumption . . . eliminate machine downtime for lubrication . . . reduce machinery repairs, power bills and accidents. Literally, each saving leads to another. As a result, not only the largest companies are profiting from centralized power lubrication, but much smaller operations as well.

The question might well be asked, "What basic factor is causing this accelerated conversion from individual contact methods to centralized, power-operated systems?" The answer is summed up in the word "control." The meaning and significance of "controlled application" can be most strikingly illustrated by contrasting the degree of "control" provided by methods using oil cans and hand-operated grease guns with that provided by modern centralized systems for mass lubrication.

THE CASE FOR CENTRALIZED LUBRICATION

Since the beginning of the century, and up to the present time, conventional oil cans and, a little later, hand-operated grease guns have been the primary lubricant-application tools of industry, despite the fact that the average industrial plant has grown to immense size, some with complete operations on one floor level, others with elevations equal to a 10-story modern office building. Equipment and machinery are primarily designed for continuous operation and constant mass production. Many types of bearings are found on these modern machines and the number is far greater. Most present-day machines are precision-built to operate at greatly increased speeds, and are designed to carry heavier loads, continuously.

The inability of the oil can and grease gun to meet today's machine lubrication requirements rests in the fact that there is no element of control. One can only assume that the right lubricant has been selected for every bearing, that every bearing will be located and lubricated, that the proper amount of lubricant will be applied to each bearing, that the lubricant will be applied at the proper time intervals, that the lubricant will flow to the bearing after application, and finally, that the lubricant will be free of contamination.

Aside from the fact that there is no control, the cost of oil cans and grease guns is threefold: (1) initial cost; (2) cost of carrying them around, and (3) cost of the consequences resulting from the way they are used.

Bearing failures due to improper lubrication growing out of insufficient, excessive or contaminated lubricant result from slow cumulative wear. The process cannot be readily detected by observation, nor controlled by an exacting choice of lubricant, or by the most rigid lubrication instructions. It is inherent in the method of application and cannot be controlled as long as the factors governing application and contributing to wear are unknown even to the man who carries the oil can or grease gun, regardless of his level of intelligence or his desire to do a good job.

This condition, then, has led to the increasing acceptance of centralized power lubrication with its consequent effect of reducing costs in all mine-operating categories.

These automatic systems can be installed on one piece of equipment, or engineered to cover all major machinery throughout an entire processing plant. Most of the manpower previously employed as oilers can then be transferred to other, more productive work. A centralized system watches itself. If it can't feed any one bearing properly, that particular machine will shut down, not break down.

Centralized lubrication may be looked at this way. Mine operators pay fabulous sums for fast, pre-

cision machines to give them one thing—maximum production. To keep these machines operating at top efficiency, mere preventive maintenance is not enough. The approach must be positive and can perhaps be best expressed by the term "productive maintenance," which means practicing the lubrication functions in such a way as to reduce operating costs in as many areas as possible, not just endeavoring to keep a machine from breaking down.

ADVANTAGES OF CENTRALIZED LUBRICATION

Some of these operating cost areas will now be individually and specifically considered to see how modern power lubrication affects them.

A consensus of opinion among mine superintendents and lubrication engineers obtained as a result of mail surveys and interviews conducted by the major oil companies and trade papers serving the industry reflects three primary cost areas which can and are being vitally affected by installation of centralized power lubrication systems. In order of importance they are as follows:

1. Securing maximum production per man—per machine hour.
2. Reducing the personal hazards of mining and maintenance of equipment.
3. Lowering equipment maintenance costs.

INCREASED PRODUCTION

In the case of increasing production per man, per machine hour, it is interesting to note that although the bituminous labor force has declined from 462,000 to 200,000 in the last 15 years, output per man has more than doubled. The major credit is due to the development and use of continuous miners. For example, these machines are capable of cutting and loading up to eight tons of coal per minute in straight line advance. However, remarkable as this equipment is, its overall efficiency would be greatly reduced without the application of automatic centralized lubrication.

The same is true on supplementary equipment, such as, coal loaders which handle rock or slate, and load at the rate 10 tons per minute in free coal. Both types of equipment are hydraulically operated, and hence, utilize a centralized system supplied by a built-in hydraulically actuated, high pressure lubricant pump. The pumping unit is connected in series with a four-way double-acting valve. The valve, in turn, automatically cycles the lubrication system at any prearranged number of movements of the cutting or loading head. Each bearing, therefore, receives exactly the right amount of lubricant as controlled by the individual adjustable lubricant injector connected by a feed line to the bearing. As a result, a constant film of refinery pure lubricant is maintained on all bearing surfaces and is distributed evenly by the motion of the bearing.

It is not hard to appreciate the economic advantages of these centralized systems when one considers that (1) maximum, continuous production is obtained by elimination of machine down-time for lubrication; (2) break-downs with consequent costly repairs due to flooding or starving bearings attendant to manual lubrication methods are greatly reduced; and (3) man power previously employed in lubrication can be better utilized elsewhere.

When one stops to consider that a continuous miner costs up to $250,000; a coal loader up to $50,000, and a cable reel shuttle car about $35,000, it's just common sense that the best and most efficient lubrication is an economic "must" to protect this investment and secure the maximum dividends from same.

The same advantages of power lubrication can be dramatically illustrated in the case of equipment for stripping operations. Automatic Systems are today servicing as many as 250 bearings in seconds on individual power shovels with 60 to 70 cubic yard buckets. Savings in down-time, labor and lubricants have been recorded as high as $75,000 per year per shovel, and in the case of one stripping operation where the shovels have consistently broken world earth-moving records, a large part of the credit for achieving these accomplishments has been accorded the installation of automatic lubrication systems.

At first, such colossal savings seem absolutely incredible, but on examining the lubrication time and work sheets it becomes not only believable, but documented fact. For example, time previously required

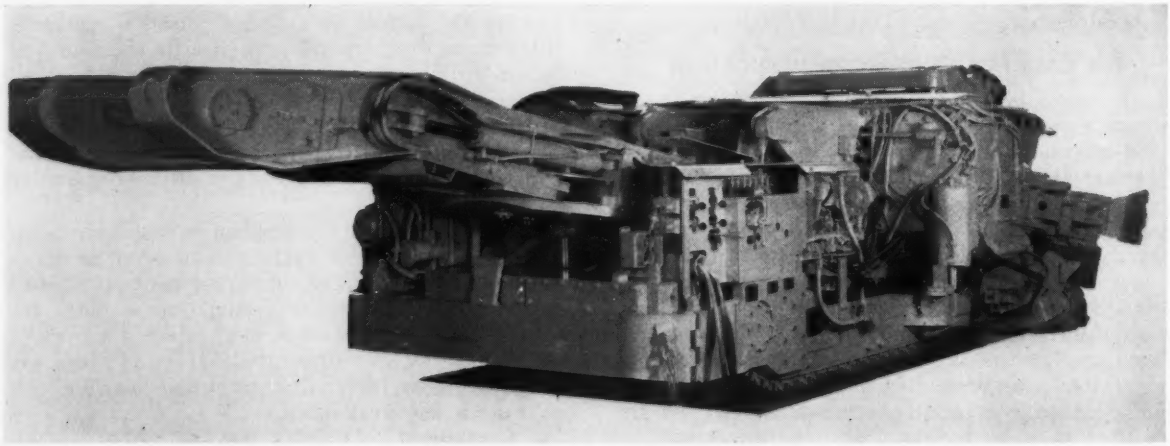

Fig. 2. Side view of control and borer.

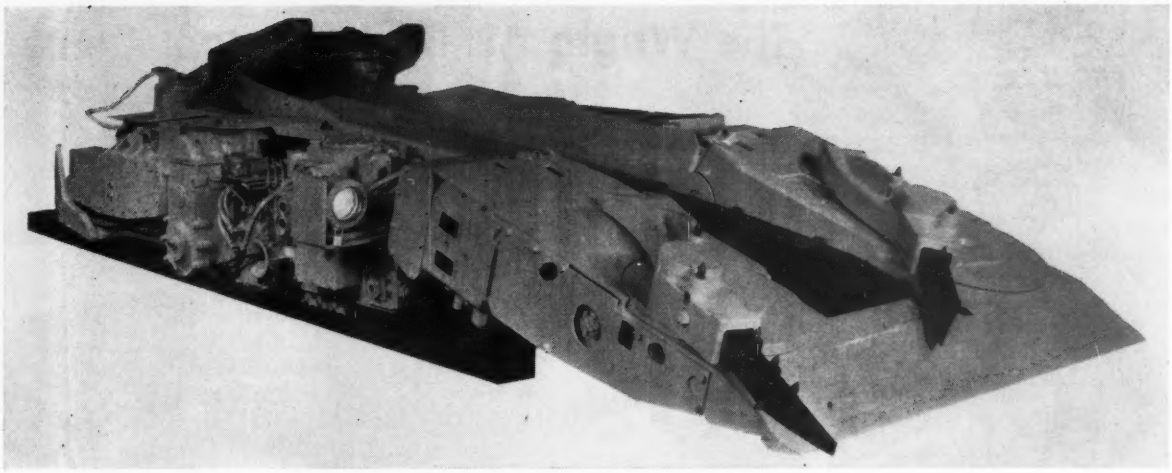

Fig. 3. Loading machine with automatic lubricator behind headlight.

for hand lubrication of bearings on the dipper-stick swivel assembly required stopping these multi-million dollar shovels one hour every shift. Lubricating 98 circle roller bearings with a hand gun while machine was rotating required two hours per eight hour shift.

The change which automatic lubrication systems are accomplishing in preparation plants will now be briefly considered. For the sake of illustration, an outstanding case history involves a relatively new central plant embodying washing, screening, and centrifugal and heat drying, in addition to crushing, hand-picking, boom loading and so on. The capacity of the plant is 1,500 tons per hour, and facilities include a rotary railroad-car dump and the necessary car handling facilities.

Automatic centralized lubrication systems installed in this plant serve over 1,000 bearings. Three lubricant pumping stations are employed with standby pumps which can be cut in if necessary. Each station has sufficient capacity to take over another in case of mechanical failure, thereby, insuring uninterrupted rhythm of the lubrication function. Systems cycle automatically every 15 minutes except for certain large, slow-moving bearings, where a one hour interval has been found satisfactory. As a result of this installation, savings per year in direct labor, machine downtime and lubricants exceed $100,000 per year.

Even in the case of 50 to 60 ton tractor semi-trailer coal haulers, automatic power lubrication is demonstrating remarkable cost reductions amounting to a 43 per cent saving in lubricants after recorded service of 100,000 miles, and a bare minimum of lubricating delays and truck and trailer parts replacement.

From the foregoing, it can readily be seen that there is no mystery how and why centralized power lubrication can help achieve maximum production per machine and per man-hour.

SAFETY

The second primary problem or objective that concerns mine operators is to increase the safety factor in their overall operation.

It is certainly a well known fact that no industry is more safety-conscious than the mining industry, and consequently, tremendous emphasis is placed on investing in the safest possible equipment and maintenance practices available. It is not necessary to dwell at great length on how automatic lubrication systems help eliminate accidents. One has only to visualize an oiler climbing up the boom of a 60 cu. yd power shovel with a grease gun in hand, or endeavoring to lubricate manually the circle roller bearings on the shovel as it is rotating to realize what it means to accomplish the lubrication function automatically and mechanically. If further evidence is needed of the dangers involved in hand lubrication of mining machinery, one need only walk through the roar of a preparation plant with its crushers, conveyors, shaker screens, or even climb around on a continuous miner with its bit-filled cutting arms. This is not work designed for the "human element."

REDUCED MAINTENANCE

It has already been pointed out in some detail how such systems help increase production per machine, per man-hour by eliminating machine downtime for lubrication, reducing direct labor costs involved, and costly parts replacements due to bearing failures resulting from excessive or inadequate lubrication inherent in individual contact methods. All of these savings are, of course, reductions in maintenance expense. There are others . . . and an important one is the reduction in quantity and number of various type lubricants used.

It is a calculated fact that conventional lubricating methods waste lubricants. In hand gun application, it is estimated that trial shots on the ground and dumping of lubricants contaminated by dust, dirt and grit wastes all but perhaps 40 to 50 per cent of the materials purchased. With centralized systems, overlubrication and waste is eliminated. In addition, the number of different lubricants can be materially reduced by standardizing on a few multi-purpose types. Centralized systems, which are sealed from pump to bearing, assure the application of refinery pure lubricant. Bearings are kept clean by the exclusion of abra-

(Cont. on p. 294)

The Wright Air Development Center

Gear Lubrication Research and Development Program

A general outline of the several programs at present underway are given. A description of the apparatus and test procedures for determining the scuff limited load and gear fatigue are given. The effect of operating variables on both test procedures are delineated. Plans for future work in these fields are discussed.

by H. R. Smith

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The program on gear lubrication to date has been directed along the lines of development of satisfactory test methods for determining the scuff limited load or the so-called load carrying ability, and the fatigue life obtained with various lubricant formulations. Very little data is available at this time concerning the basic lubricant characteristics which influence the scuff limited load and fatigue life.

The data which is available concerning actual performance of lubricants and gears, unfortunately, has been obtained by a number of laboratories each of which used their own test rig design, test gears, lubricants and test conditions. All too often the data thus gathered is incompatible within itself and sometimes conflicting.

In spite of these difficulties, progress is slowly but surely being made. Much of the data obtained in this program has correlated reasonably well with gear box performance.

Until recently, the program was directed towards obtaining test procedures for the evaluation of various lubricants submitted for qualification under some definite Air Force Specification. However, sponsorship was recently attained for a program of investigation into the basic characteristics of lubricants that effect various phases of gear lubrication. Some of the factors being investigated are pressure viscosities, both static and dynamic, tooth surface temperatures and pressures, effective lubricant film thickness, lubricant shear characteristics under dynamic conditions and stress corrosion. This program is in its initial phase which consists of a survey of the literature and of the various pertinent programs now underway under other sponsorship. The program has not reached a point where data is available for presentation.

To date, all investigation of gear lubrication has been carried out using the Ryder Gear Test Apparatus. In the course of these investigations an attempt was made to determine the effects of various test conditions and lubricant characteristics of both scuff limited load and gear fatigue life.

TEST APPARATUS

Fig. 1 shows the operational portion of the Ryder Gear Universal Tester. This consists basically of a drive mechanism, a test head, and support and test oil circulating systems.

Fig. 2 is the control console of the rig which contains the operational controls and the necessary instrumentation for indicating temperatures, pressures and speeds at different points on the test apparatus.

Fig. 3 is a detailed drawing of the gear test head which operates on the four square principle. The test gears consist of a narrow gear on the driving shaft and wide gear on the driven shaft. All data is taken from the appearance of the narrow gear after operation. Note that the shafts are connected by the test gears and also by a pair of helical gears so that a longitudinal load applied to the driven shaft will apply a load to the test gear tooth.

Test gears are made from AMS 6260 steel and are case hardened and ground but differ slightly for the two test procedures as will be explained later.

Presented before the 13th Annual Meeting of the American Society of Lubrication Engineers, April, 1958, at Cleveland, Ohio.

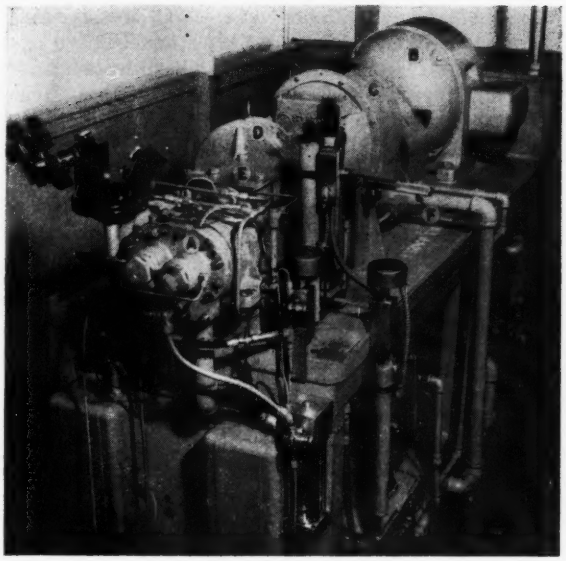


Fig. 1. Ryder Gear Universal Tester, A. Ryder Gear machine; B. drive motor; C. dynamatic coupling; D. step-up gear box; E. adaptor; F. indexing ratchet.

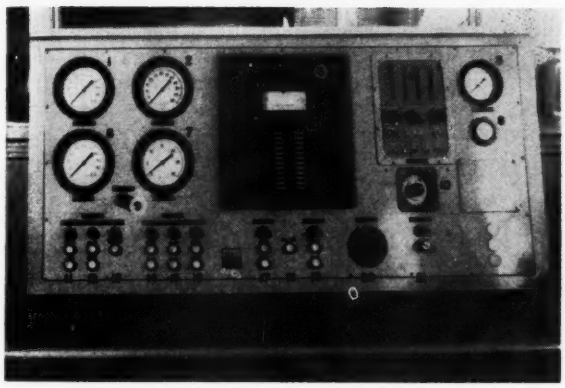


Fig. 2. Control console, Ryder Gear Universal Tester.

1 SUPPORT OIL PRESSURE GAGE
2 TEST OIL PRESSURE GAGE
3 MULTI-POINT TEMPERATURE INDICATOR
4 ELECTRONIC RPM COUNTER
5 GEAR BOX PRESSURE GAGE
6 LOAD OIL PRESSURE GAGE (HIGH RANGE)
7 LOAD OIL PRESSURE GAGE (LOW RANGE)
8 RUNNING TIME METER
9 LOAD ADJUST CONTROL
10 ELECTRIC TIMER
11 SUPPORT OIL PUMPS START-STOP BUTTONS
12 SUPPORT OIL HEATERS ON-OFF BUTTONS
13 LOAD BY-PASS OPEN-CLOSE SWITCH
14 TEST OIL PRESSURE PUMP START-STOP BUTTONS
15 TEST OIL SCAVENGE PUMP START-STOP BUTTONS
16 TEST OIL HEATERS ON-OFF BUTTONS
17 INSTRUMENTS ON-OFF BUTTONS
18 EMERGENCY STOP BUTTON
19 DRIVE MOTOR START-STOP BUTTONS
20 RPM ADJUST CONTROL
21 TIMER START-STOP SWITCH

Before acceptance for test or research purposes, the test gears are checked with a Red Line Apparatus for concentricity, involute form, tooth spacing, root radius and variations in chordal thickness. If gears do not conform to rigid standards they are discarded.

Table 1 gives the tolerances to which these gears are held.

TABLE 1. GEAR TOLERANCES

INVOLUTE FORM ERROR	
At tip diameter	±0.0003 in
At tip	+0.00 to −0.0006 in
TOOTH SPACING	
Tooth to tooth	0.0004 in
Accumulated	0.0018 in
BASE PITCH	±0.0005 in
LEAD	0.0005 in
CHORDAL THICKNESS	0.00 to −0.0005 in
CONCENTRICITY	0.0020 in
TOOTH EDGE RADIUS	>0.0050 in
SURFACE FINISH, MICRO INCHES RMS	20-35

PROCEDURE FOR GEAR SCUFFING TESTS

The procedure for determining the scuff limited load and for investigating various factors affecting this property will be considered first.

Table 2 gives a description of the gears and the standard conditions under which the scuff limited loads were obtained.

TABLE 2. SCUFF TEST GEARS AND PROCEDURE.

TEST GEARS	
Material	AMS 6260 steel
Treatment	Case hardened and ground
Pitch diameter	3-½ inch
Number of teeth	28
Diametral pitch	8
Pressure angle	22.5
OPERATING CONDITIONS	
Test gear speed	10,000 rpm
Test oil flow rate	270 ml/minute
Test oil-in temperature	165F
Support oil-in temperature	165F
Support oil pressure	110 psig
Loading	370 ppi increments every 10 minutes
LIMITING SCUFFING	22.5% of working tooth area
METHOD OF COMPARISON	Tooth load to limiting scuffing

The test head was brought up to speed and temperature. Load was applied to the driven shaft of the test head by means of a bellows system. The test was started at 370 lbs per inch of tooth face width (ppi) on the test gear teeth and was increased in 370 ppi increments until the failure point was reached. The test was run 10 minutes at each load increment. At the end of each ten minute run the machine was stopped and the scuffed area of each tooth was determined as a percentate of the total tooth face area. An average scuff of 22.5 per cent was considered as the failure

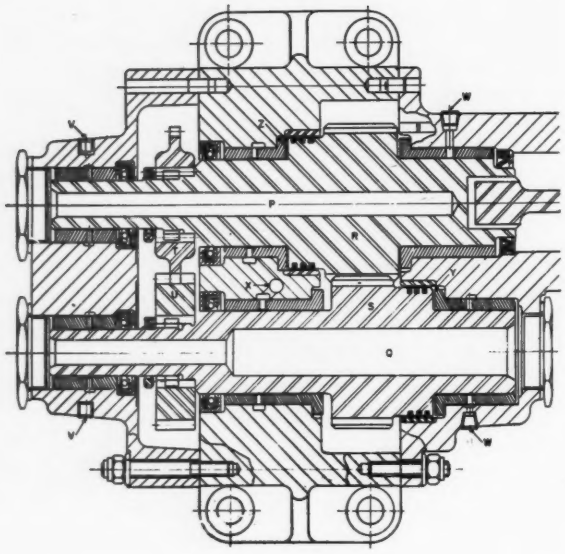


Fig. 3. Sectional view of gear test head.

P DRIVE SHAFT
Q DRIVEN SHAFT
R SLAVE GEAR
S SLAVE GEAR
T TEST GEAR (NARROW)
U TEST GEAR (WIDE)
V SUPPORT OIL IN
W SUPPORT AND LOAD OIL IN
X SUPPORT AND LOAD OIL IN
Y LOAD CHAMBER
Z LOAD CHAMBER

point and the load in ppi of tooth face width at this point taken as the scuff limited load. Scuffing is defined as that degree of abrasion or scratching which obliterates the tool marks on the gear teeth.

EFFECT OF OPERATIONAL VARIABLES

The effect of various operating variables on scuff limited load was investigated. The data presented has not been brought up to date but subsequent data has followed along the same general pattern in each case.

Fig. 4 shows the effect of test oil flow on scuff limited load. In each run the test was started at the highest flow rate and decreased as the test progressed. All tests were conducted under standard conditions at a constant load of 2200 ppi. Note that at one point in each run the scuffing starts to increase rapidly in proportion to the decrease in flow rate indicating that a critical point has been reached. One curve indicates that the selection of a standard flow rate of 270 ml/min may be open to question.

Fig. 5 shows the effect of speed on scuffing. As may be seen, the scuffing increased with speed up to about 10,000 rpm. From 10,000 to 15,000 rpm the scuffing decreased. This was surprising, but investigation into the matter caused acceptance of the trend, although the cause or causes are as yet unknown. Three different types of oil were run in this investigation. SD-17 is a silicone diester blend, GTO-34 is a qualified MIL-L-7808 oil of diester type, and PP0500 is a qualified MIL-L-6082 petroleum oil equivalent to a commercial grade SAE-30. It is interesting to note that the form of the curves for these three distinctly different types of oil are reasonably similar.

Fig. 6 illustrates the effect of temperature on scuffing. The oil used was a qualified MIL-L-6082 petroleum oil equivalent to a commercial grade SAE-50. Runs were made at constant operating conditions at three different loads, each of which was held constant for the duration of the run. Runs were started at test oil and support oil temperatures of 165F and then the two temperatures were increased at the same rate. It can be readily seen that scuffing tendencies increased with increasing temperatures. Subsequent investigation of other types of oils have shown this same tendency.

FUTURE INVESTIGATION OF GEAR SCUFFING

Operation of gears under higher temperatures, loads and speeds is anticipated in the immediate future. Plans for the coming year call for the investigation of the scuffing characteristics of lubricants of the MIL-L-9236 type at test conditions including temperatures up to 400F, loads of 2800 ppi of tooth face width and higher, and speeds up to 15,000 rpm. Increased severity of these conditions will entail modification of test rig design to permit it to withstand the increased stresses and strains. Gear design and tolerances will remain essentially the same except that AMS 6260 steel will be replaced by M-50 or some equivalent steel.

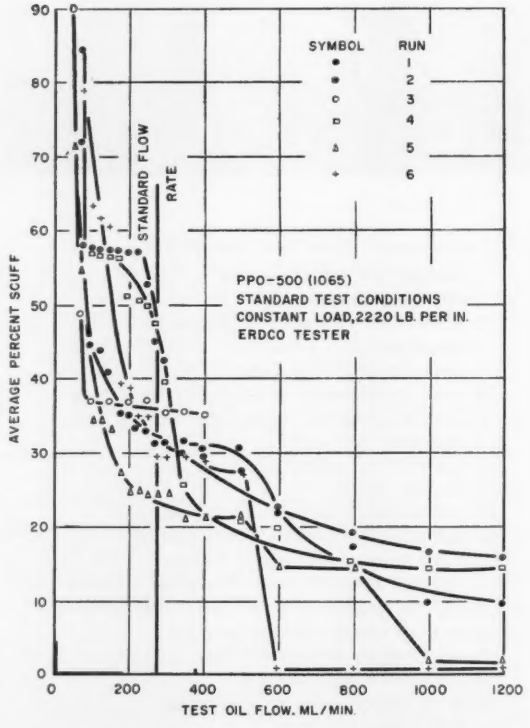


Fig. 4. Effect of test oil flow rate on scuffing, exit lubrication.

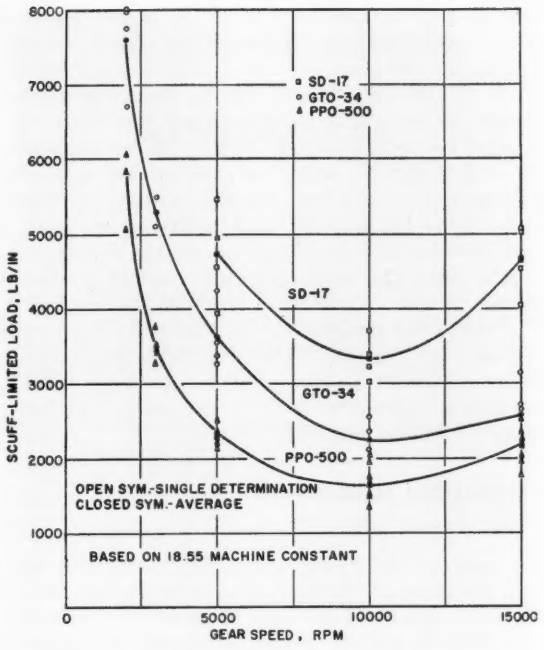


Fig. 5. Effect of speed on scuff-limited load.

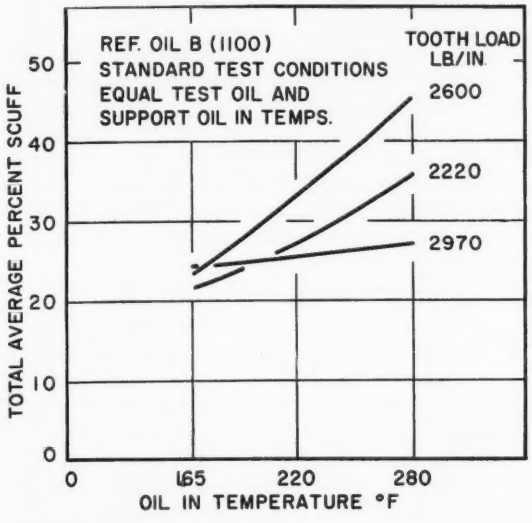


Fig. 6. Effect of temperature on scuffing.

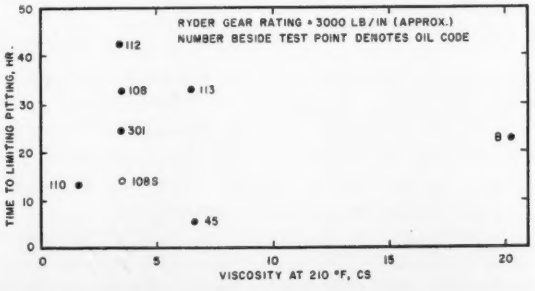

RYDER GEAR RATING = 3000 LB/IN (APPROX.)
NUMBER BESIDE TEST POINT DENOTES OIL CODE
TIME TO LIMITING PITTING, HR.
VISCOSITY AT 210 °F, CS

Fig. 7. Effect of oil viscosity on gear tooth fatigue.

GEAR FATIGUE INVESTIGATION

The gear fatigue program has been primarily aimed at developing test procedure for evaluating the effect of various lubricants on gear fatigue life. The standard Ryder Gear Test Apparatus was used. The test gears differ from the standard scuff limited load gears in two details. They have a pressure angle of 14.5 and have a tip relief of 0.0016 inches. This change was found to be advisable in order to reduce the time necessary to produce limiting pitting without increasing operational severity to a point where stress and strain on the apparatus became excessive. The low pressure angle was employed in order to increase the maximum compressive stress for a given tooth load.

The original objective of the program was to devise a test that would produce limiting pitting in less than 100 hours. After some preliminary work the test procedure, outlined in Table 3 was decided upon. This has been subsequently revised to define limiting pitting as the formation of *B* sized pits on three non-consecutive teeth since data indicated that there was no advantage gained by prolonging the test past this point. *B* sized pits are defined as pits that are readily discerned by the naked eye.

TABLE 3. Fatigue Test Procedure (Exploratory).

TEST GEARS	
Material	AMS 6260 steel
Treatment	Case hardened and ground
Pitch diameter	3-½ inch
Number of teeth	28
Diametral pitch	8
Pressure angle	14.5°
Tip relief	0.0016 inch
OPERATING CONDITIONS	
Test gear speed	5,000 rpm
Test oil flow rate	1,300 ml/minute
Test oil-in temperature	190F
Support oil-in temperature	190F
Support oil pressure	110 psig
Tooth load	3,710 lb/inch (50 psig load oil pressure)
LIMITING PITTING— "B" size pits on:	1. 1 tooth 2. 3 non-consecutive teeth 3. 14 teeth
METHOD OF COMPARISON	Time to limiting pitting

GEAR FATIGUE TEST PROCEDURE

The test gears were lubricated with the test oil by means of two jets directed at the meshing teeth, one on the meshing and one on the unmeshing sides. The gears were loaded progressively in increments of 370 ppi pressure. Each increment was run for ten minutes. After each run the machine was stopped and the gear examined for scuffing. This was continued until a load of 3710 ppi of tooth face width was reached. The endurance run was then made at this constant load. The machine was stopped every two hours to permit examination of the narrow test gear for pitting and scuf-

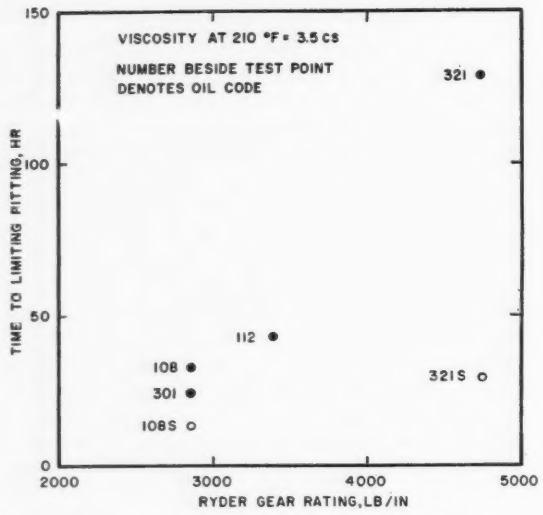


Fig. 8. Effect of load-carrying ability on gear tooth fatigue.

fing and the run continued in cycles of this duration until the criteria for limiting pitting was reached.

EFFECT OF OPERATING VARIABLES ON FATIGUE

The investigation of the effect of operating variables on gear fatigue is continuing. At present, data is confined to the variables illustrated in Fig. 7 and Fig. 8.

Fig. 7 shows the effect of oil viscosity on gear tooth fatigue. Subsequent data as well as that presented here has shown that viscosity has little effect on the fatigue life of gears. The oil showing an extremely long fatigue life should probably be excluded from consideration here as its gear lubrication characteristics depend largely on a very exotic additive material.

Fig. 8 shows load carrying ability plotted against fatigue life. Discounting the high fatigue life oil, it can be seen that there is apparently little correlation between scuff limited load and gear tooth fatigue. Data obtained subsequently has borne out this conclusion.

Gear fatigue pitting is the tearing or breaking away of irregular particles from the tooth face surface. Pitting is usually confined to the pitch line area where compressive stress was greatest. Only in very rare cases did pitting occur outside this region. Scuffing is more apt to occur in the root and tip regions of the teeth. In cases of low scuff, it was confined to the root section because of the tip relief on the test gears. While initial scuff values had little apparent effect on the limiting pitting values, once pitting had occurred the scuff rate and severity was greatly increased.

Whatever the lubricant characteristics effecting gear fatigue may be, it is reasonably certain that the viscosity and scuff limited load are not involved.

FUTURE INVESTIGATION OF GEAR FATIGUE

As in the scuff limited load program, plans in the field of gear fatigue work involves higher temperatures, loads, and speeds. Rig modification will be necessary in this program for the same reasons previously given for the other program. Gear materials will also change as for the scuffing program. However, it is planned to use 22.5 instead of 14.5 pressure angle gears for both programs since more severe test conditions will probably keep test duration within the desired limits. This will not only standardize on one gear for both tests but is desirable for correlation with gear box results since 22.5 angle gears are used in production gears.

While the progress in the understanding of gear lubrication fundamentals has been slow and may continue to be so it is hoped that in the not too distant future the answers to some of the more vital factors involved will be obtained.

CENTRALIZED LUBRICATION

(Cont. from p. 289)

sive and corrosive substances. Dirt, corrosive fumes and moisture are kept from bearing surfaces by the injection of lubricants while the shafts are in motion.

With regard to direct labor costs calculated on portal-to-portal pay, automatic lubrication certainly effects a saving in this category by diverting manpower from maintenance to more productive work.

Further, centralized systems have helped cut down the cost of power by reducing the drag of machine friction and misalignment of moving parts which occur when lubrication is practiced in a haphazard or inadequate manner.

CONCLUSION

It should be remembered that if the multiple economic benefits of centralized power lubrication are to be obtained, whether in the coal mining industry, or any other, four essential facts must thoroughly be understood and recognized by management:

1. The highest quality oil or grease, regardless of cost, cannot become a lubricant until applied to a bearing; therefore, provisions for the application of lubricant should take equal rank with selection of the lubricant.

2. The application of lubricant to maintain bearing surfaces is a distinct operating function and should not be confused with general maintenance.

3. Conditions within modern industry today present a situation entirely new and far afield to those existing when the application of lubricant was so simple that the conventional oil can and grease gun embodied all provisions requisite to proper application.

4. These new, modern conditions are of such magnitude and complexity that the inherent deficiency of individual contact methods cannot be made to suffice, even though supplemented by elaborate record keeping, detailed lubrication instructions and check procedures, as has become common practice under routines established as preventive maintenance.

Provisions for the application of lubricant can be deemed adequate under all conditions and in all respects when, and only when, these provisions apply the *right lubricant in the right quantity at the right time.*

Lubrication Abstracts

Edited by W. E. Campbell

Selected literature compiled by members of the Technical Committees and Industry Councils of the Society.

"Waste Disposal at Anacortes," E. D. Newman, C. J. Reno, & L. C. Burroughs (Shell Oil Co. Puget Sound), Oil & Gas Journal v 56, n 20, May 19, 1958.

Waste water pumped into the bay must be boiled to prevent fish poisoning in nearby fishing areas. All areas subject to oil spill drain into an oily water sewer where most of the oil is skimmed off. Additional oil is removed by the use of alum and silica. The deoiled water is joined by the effluent from the sanitary sewers. It is then treated biologically, settled, and filtered. The sludge is incinerated, the spent chemicals are barged out to sea, and the cleared water is pumped into the bay during tide runs to insure rapid dispersion. Tables, photographs, and drawings are included. (*Abstracted by A. S. Gressel*)

"Electrical Effects Accompanying the Stick-Slip Phenomenon of Sliding of Metals on Plastics and Lubricated Surfaces," by G. W. Sohl, J. Gaynor, and S. M. Skinner, Trans. ASME, v 79, n 8, Nov. 1957, pp 1963-70.

Electrical transients produced from stick-slip are investigated. The apparatus consists of an elastically restrained hemispherical rider sliding against a rotating disk. Electrical discharges are observed for metal sliding on plastics and metal sliding on metal, both lubricated and unlubricated. The discharge occurs at the beginning of the slip part of stick-slip. The discharges may be small and numerous or large and occur singly. The quantity of the charge increases with frictional resistance. (*Abstracted by Douglas Godfrey*)

"Visual Study of Ball Motion in High Speed Thrust Bearing," Shevchenko, R. P., and Bolan, P., Soc. Automotive Engrs., Paper n 37 for meeting January 14-18, 1957, p 16.

Ball motion in a high-speed thrust-bearing is studied experimentally through the use of high speed motion pictures. A preliminary analysis is made of some typical ball motion pictures for a particular bearing with and without a cage for various loads and speeds. Discrepances are found to exist between the experimental results and the results predicted from usual ball bearing theory. (*Abstracted by H. Connors*)

"Resistance to Rolling and Sliding," by A. C. Dunk and A. S. Hall, (Purdue Univ., Lafayette, Ind.), Trans. ASME, v 80, n 4, May 1958, pp 915-20.

The effects of sliding velocity on the friction between a pair of rotating disks in peripheral contact is studied in terms of the forces between the surfaces. The tests are run under hydrodynamic lubricated conditions. The frictional force is expressed in terms of the inclination and offset of the resultant line of force. Sliding velocity is of primary importance in determining inclination and sweep velocity is of primary importance in determining offset of the line of force. (*Abstracted by Douglas Godfrey*)

"The Use of Polytetrafluoroethylene as a Lubricant," by E. Kay and E. D. Tingle (Royal Aircraft Establishment, Farnborough, Hants, England), Brit. J. Appl. Phys., v 9, n 1, Jan. 1958, pp 17-25.

The friction and wear properties of thin deposited films of polytetrafluorethylene (PTFE) are evaluated on a Bowden-Leben friction apparatus, a modified Wells machine, and a four-ball machine. Films are produced with an aqueous suspensoid of PTFE on various metal surfaces and with and without additional silicone and phosphate treatments. The results show that certain combined treatments produce low friction, high load carrying surfaces. In particular, phosphating prior to deposition of PTFE is beneficial. (*Abstracted by Douglas Godfrey*)

"How to Fabricate Stainless Steels." Part II—Spinning. W. E. McFee (Armco Steel Corporation), Metal Products Manufacture, v 15, n 2, 1958, 19-22.

More detail on the spinning mentioned in Part I, ibid, v. 15, No. 1, 1958, 33-5. A preferred lubricant is a suspension of one part soap in two parts oil. Lithopone-linseed oil mixtures, like those used in deep drawing, work well but cleaning requirements are high. Considerable information is included covering the general shop practices for spinning and related operations. (*Abstractor A. H. Lipton*)

"Key to Disposable Cutters." Harold York (General Electric Company, Detroit) Steel, v 142, n 7, 1958, 136-39.

Toolholders for disposable carbide cutters are the most critical factor in applying this type of tool. A suggested design is shown and the two main requirements of the holders are covered: the holder must grasp the tip rigidly and position it accurately. Fundamentals which led to the suggested design are briefly discussed. (*Abstractor A. H. Lipton*)

"Concentration Effects of Cutting Oil Additives in Performance Evaluation." A. Dorinson (Sinclair Research Labs, Inc.), Lubrication Engineering, v 12, 1956.

Results of performance tests including turning, planning and tapping form a basis of a hypothesis for the mechanism of cutting oil action. The behavior observed for a particular cutting oil will depend on the relationship between wear by metal contact of tool and chip, and wear resulting from chemical reaction of the tool material and additive. Data include tool life and surface finish studies using high speed steel tools in lathe tests. Determination of the concentration-dependent effect of cutting oil additives on performance tests entailed use of different concentrations of six cutting oil additives. (*Abstracted by Robert McKay*)

"Compatibility of Greases." R. Tourret and A. J. S. Baker, (Admiralty Oil Laboratory, Brentford) Journal of Petroleum Institute, v 41-4. 44, n 409, 1958, pp. 9-13.

It is shown that the incompatibility of greases can occur in a random manner. The ASTM Wheel Bearing Test is used to demonstrate the incompatibility of some greases. These greases are mixed by either folding them into each other, bulking them, or working them in the grease worker. The last method is found to be most reliable because it gives uniform results and appears to be more representative of service conditions such as those occurring shortly after repacking of bearings. Changes in penetration of the greases are found to be not a reliable measure of the incompatibility of greases. (*Abstracted by E. O. Forster*)

(Cont. on p. 297)

Intensification of Research Effort Needed on Boundary Friction and Wear

Boundary friction and wear, the greatest source of industrial waste and the strongest single barrier to any substantial increases in the productivity of our machinery, is still a very complex phase of engineering.

It is a national military and industrial problem.

The slow progress in this particular phase of engineering can be attributed to the delayed recognition of the seriousness and complexity of the problem, to educational neglect, and to the refusal of engineering as a whole to accept responsibility for these deficiencies. The solution was thought to be the primary responsibility of the lubricant manufacturers.

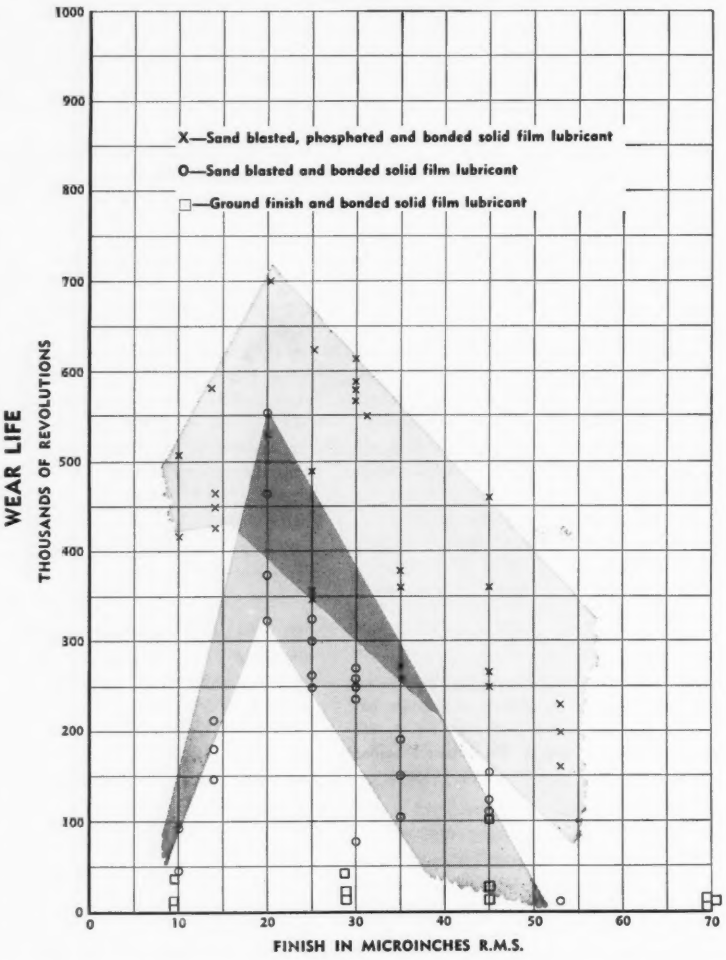
As one of these lubricant manufacturers, we take this responsibility seriously. After years of experience, we have found that the eventual elimination of boundary friction and wear as a complex will be based on *testing . . . testing . . . and more testing.* We feel that it is unrealistic to complain that the few E.P. testing machines in use do not solve the whole complex for us.

We want all the reliable testing machines we can afford and we now have 14 of one type, our Model LFW-1, in operation. Finally, we are beginning to see light after more than 100,000 testing hours on these machines. Yet, we realize that we have only begun to scratch the surface!

For example, it took 7,000 testing machine hours to plot the chart on this page which indicates the significance of surface finish and the methods used to produce it. A sharp wear-life peak appears for surfaces ground to 8 to 10 microinches r.m.s. and then sandblasted to a 20 microinches r.m.s. finish. It drops off sharply for finer or coarser finishes produced with other sizes of blasting media. Wear life is lowest for ground finishes.

Of course, surface roughness is only one of the many ingredients which make up the complexity of boundary friction and wear. A large number of these ingredients has shown up in our test data and will have to be investigated separately.

To complete the study of the effect of the surface finish alone for conditions other than those used in our tests, such as: a large variety of mating metal combinations, bearing pressures, sliding velocities, etc., an estimate of 4,000,000 testing machine hours is probably on the low side.



WEAR LIFE VERSUS SURFACE FINISH curves show the significance of surface finish and the methods used to produce it. Tests were run on Alpha Model LFW-1 testing machines. The following key indicates the testing procedures used: X shows results of samples which were ground to 8 to 10 microinches r.m.s. and then sandblasted to finish shown. After sandblasting, these samples were phosphated and then coated with a bonded solid film lubricant; ○ shows the results on samples which were ground to 8 to 10 microinches r.m.s., sandblasted to the r.m.s. finish shown and then coated with a bonded solid film lubricant; □ shows results on a ground surface coated with a bonded solid film lubricant.

About half of the energy produced in the world today is consumed by boundary friction and billions of dollars yearly are lost to boundary wear. Even if we are willing to accept these losses, we can hardly accept the condition where tremendous engineering advances are made in other fields only to be retarded by the slow progress in the field of boundary lubrication.

The Alpha-Molykote Corporation, 65 Harvard Avenue, Stamford, Connecticut, manufacturers of MOLYKOTE® Lubricants and Alpha Lubricant Testing Machines.

LUBRICATION ABSTRACTS

(Cont. from p. 295)

"Some Characteristics of Conventional Tilting-Pad Thrust Bearings," D. deGuerin and L. F. Hall, The Institution of Mechanical Engineers, Conference on Lubrication and Wear, October 1-2, 1957, Paper No. 82.

In the course of comparative tests of three types of plain thrust bearing, described in another paper, some of the results obtained suggested the need for a more detailed exploration of the functioning of bearings with tilting pads of conventional design. Tests were conducted with various arrangements of pads and with central and offset pivots. Pressure plots over the faces of pads were also obtained. It was found that the use of a central pivot, which is employed when operation in both directions of rotation must be provided for, results in a certain loss of performance as compared with the normal pivot position at 0.4 of the width from the trailing edge. The load-carrying capacity of individual pads was also found to be adversely affected by their proximity to adjacent pads in the bearing. A most important observation, which had not been expected, was that tilting pads of conventional design do not tilt, except possibly at the lowest loads. The hydrodynamic wedge is formed under the influence of thermal distortion and load deflection of the pad, and these are sufficient to modify the pressure distribution considerably and unfavourably. The accepted theory is, therefore, inadequate for calculating the pressure distribution and a new approach is necessary for improved design. (*Authors' Abstract*)

"The Torque and Thrust Diagram as a Criterion of Drill Form and Performance." H. H. Klein, The Engineers Digest, v 119, n 1, 1958, 7-11, from Werkstattstechnik und Maschinenbau, v 47, n 11, 1957, 597-603 (language unspecified).

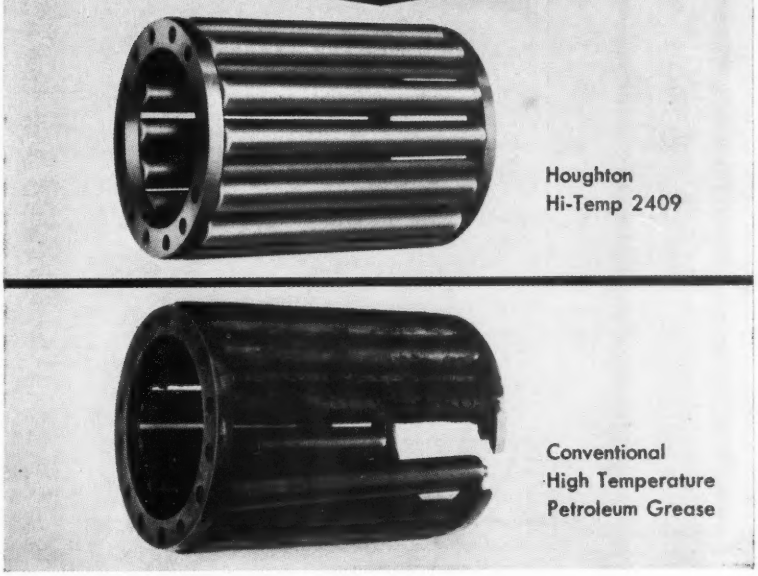
A descriptive of a dynamometer and its optical recording system. Primarily used by the author to evaluate drill forms, the torque and thrust diagrams may be of interest in cutting fluid evaluations. (*Abstracted by A. H. Lipton*)

"Plastics in the Toolroom." Anon., Steel, v 142, n 5, 1958, 108-11.

Reinforced epoxy dies are applied to punch press operations with appreciable savings. A brief description of types and construction is included, together with a guide to epoxy compositions. A non-sticking surface is claimed for epoxy dies, therefore galling is reduced, and (in many cases) a metalworking lubricant is not required. Epoxy dies do not rust. (*Abstracted by A. H. Lipton*)

(Cont. on p. 300)

NOW! 1000°F. Lubrication with New Hi-Temp 2409



Bearing failure in high temperature processing equipment due to caking of carbon, de-composed thickeners, gums and resins at high temperatures can be prevented by the use of Houghton's new Hi-Temp 2409 grease!

Hi-Temp 2409 represents a completely new concept in high temperature lubrication. In this new grease, *the thickener provides the lubrication—not the fluid!* No silicones, diesters, soaps, heavy metals or solvents are used.

A clean-burning synthetic fluid is used as a carrier. The grease becomes fluid at 200°F. carrying the lubricant to all bearing surfaces. At 500°F. the synthetic carrier is completely evaporated and a soft film of dry lubricant remains on the bearing capable of withstanding temperatures well above 1000°F.!

If you have a high temperature lubrication problem, it will pay you to investigate this new grease—Hi-Temp 2409. Call your Houghton Man for a demonstration or write E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa., for your copy of Houghton's new booklet on "Thermal Lubrication".

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HOT FORGING AGENTS
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AMERICAN SOCIETY OF LUBRICATION ENGINEERS

Statement of Cash Receipts and Disbursements
Year Ended December 31, 1958

RECEIPTS:			
Membership dues—			
Individual		$39,338.61	
Industrial		6,450.00	
Sectional sustaining		1,506.58	$ 47,295.19
Sale of publications			3,236.45
Exhibit funds—			
1958 show collected in 1957		4,467.00	
1958 show collected in 1958		5,423.00	9,890.00
Annual meeting—			
Guest registration and banquet tickets		6,584.00	
Lubrication engineering course		450.00	7,034.00
Advertising income			38,221.20
Interest and sundry income			1,534.82
Collection and exchange sundry			31.25
TOTAL			$107,242.91
DISBURSEMENTS:			
Salaries, commissions, fees		$39,913.42	
Cost of publications		31,244.43	
Office furniture and equipment purchases		1,062.19	
Office supplies and expense		1,037.47	
Administrative travel		2,140.58	
Section payments		8,775.20	
Rent		3,420.00	
Telephone and telegraph		1,551.36	
Dues, donations and subscriptions		150.60	
Legal and auditing expense		475.00	
Federal insurance contributions and unemployment tax		570.64	
Annual meeting expense		7,385.30	
Awards expense		173.52	
Exhibit expense—1958 show:			
Paid in 1957	433.95		
Paid in 1958	1,100.87	1,534.82	
Postage and express		2,159.37	
Stationery and printing (excluding exhibit costs)		2,073.85	
Group and other insurance		368.38	
Directors' and committee expense		374.83	
Miscellaneous meeting costs		333.00	
Contingencies		49.00	
Advertising commissions		9,476.69	
Promotional material		543.05	$114,812.70
Excess of disbursements over receipts, representing net decrease in free surplus during year ending December 31, 1958.			$ 7,569.79

During the year the expenditures or disbursements exceeded the cash receipts in the amount of $7,569.79. Numerous costs were incurred during 1958 which exceeded the corresponding costs for 1957 because it was necessary to pay for the capital costs of various publications and charge same to expense in accordance with the procedure established in prior years. Inasmuch as the cash basis of accounting is employed, for practical reasons, the costs of all publications are charged off and the value of those on hand at the end of the year is not carried on the balance sheet as an asset. The schedule of publications, sales and costs, compares 1958 operations with those of 1957 and shows that a gross income of $3,236.45 was realized in 1958 as compared with $11,261.98 for 1957. This disparity was caused by the adoption of a policy in the interest of establishing the reputation and prestige of the Society for providing scientific literature and the data to members. Many of the publications bought and paid for during 1958 will be sold during 1959 and subsequent years.

J. W. Peterson,
Treasurer

Balance Sheet—December 31, 1958

ASSETS

Working Capital Assets:		
Cash on deposit and on hand—		
Bank checking account	$11,718.89	
Bank savings account	1,333.06	
Petty cash fund	35.00	
Travel advance fund	250.00	
Total working capital assets		$ 13,336.95
Reserve Fund Assets:		
Savings and loan deposits	26,400.00	
Investments in U. S. Treasury Bonds–at cost	14,709.11	$ 41,109.11
Office Furniture and Equipment:		
At cost	11,713.83	
Less: Allowance for depreciation	4,478.50	
Net book value		7,235.33
		61,681.39

NOTE: The above statement has been prepared on the basis of cash receipts and disbursements.
THE ABOVE REPORT IS IN AGREEMENT WITH THE AUDITOR'S REPORT AS PREPARED BY C. L. GRIMES & CO., CERTIFIED PUBLIC ACCOUNTANTS.

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LUBRICATION ABSTRACTS

(Cont. from p. 297)

"Lubricating and Transformer Systems for New Zealand's Largest Hydro-Electric Station." Anon., Sci Lubrication v 9, n 7, July, 1957, pp 14-15.

The Roxburgh power station in New Zealand incorporates a number of interesting lubrication and safety features. Among them are the provision for continuous oil flow by means of standby pumps, a centralized control panel, and a system of alarms for generator and turbine bearings, generator and transformer oil pumps, governor oil pressure, and water flow to the coolers. Details are given of the location and flow of lubricant to each generator and turbine bearing and the governing system. Provision is made for the automatic isolation of oil fires. *(Abstracted by A. E. Baker)*

"The Mesomorphic Behavior of the Sodium and Lithium Soaps Prepared from Oxidized Paraffin Wax." K. U. Ingold and I. E. Puddington (Div. of Applied Chemistry, National Research Council, Ottawa, Canada) Journal of Petroleum Institute, v 44, n 410, 1958, pp

The densities of the anhydrous sodium and lithium soaps, prepared from the acids produced by the oxidation of paraffin wax, are measured over a temperature range of 25-320C. There are only minor discontinuities in the density-temperature relationship compared with those exhibited by the corresponding stearates. It is concluded that this smoother relationship is due to the complex nature of the soaps and is the reason that the soaps make such excellent grease bases. *(Abstracted by E. O. Forster)*

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* Not included in this issue.

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LUBE LINES

(Cont. from p. 227)

lubrication could be very costly.

While management justifiably may not be entirely familiar with the chemistry of lubrication or with laboratory testing procedures, they should be able to evaluate the operating conditions in their plant and the products being handled, as to potential acidity. In this respect their lubrication engineer can render invaluable service. When these conditions in turn are fully understood by their lubricant supplier the chemical stability of the lubricants selected is most positively assured.

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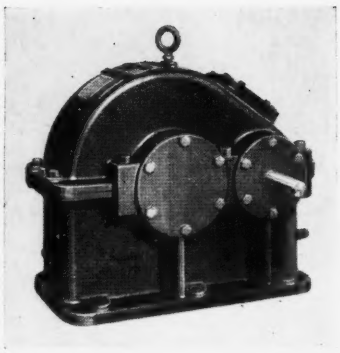
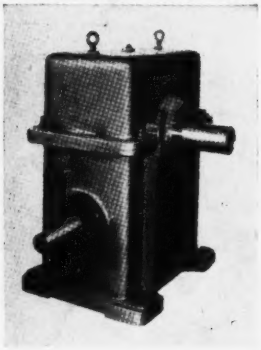
DENSOIL can be used advantageously for all types of enclosed geared units, both for teeth and bearings—sleeve and anti-friction, from the heaviest type of industrial equipment to the smallest used in household appliances, such as washing machines, ironers, etc. Most plant standards specify "DENSOIL or its equivalent". In our opinion there is no equivalent for meeting these requirements.





CASE HISTORIES:

Strip Mill Screw Downs.
DENSOIL installed 1937

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DENSOIL installed 1930

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DENSOIL installed 1936

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DENSOIL installed 1940

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